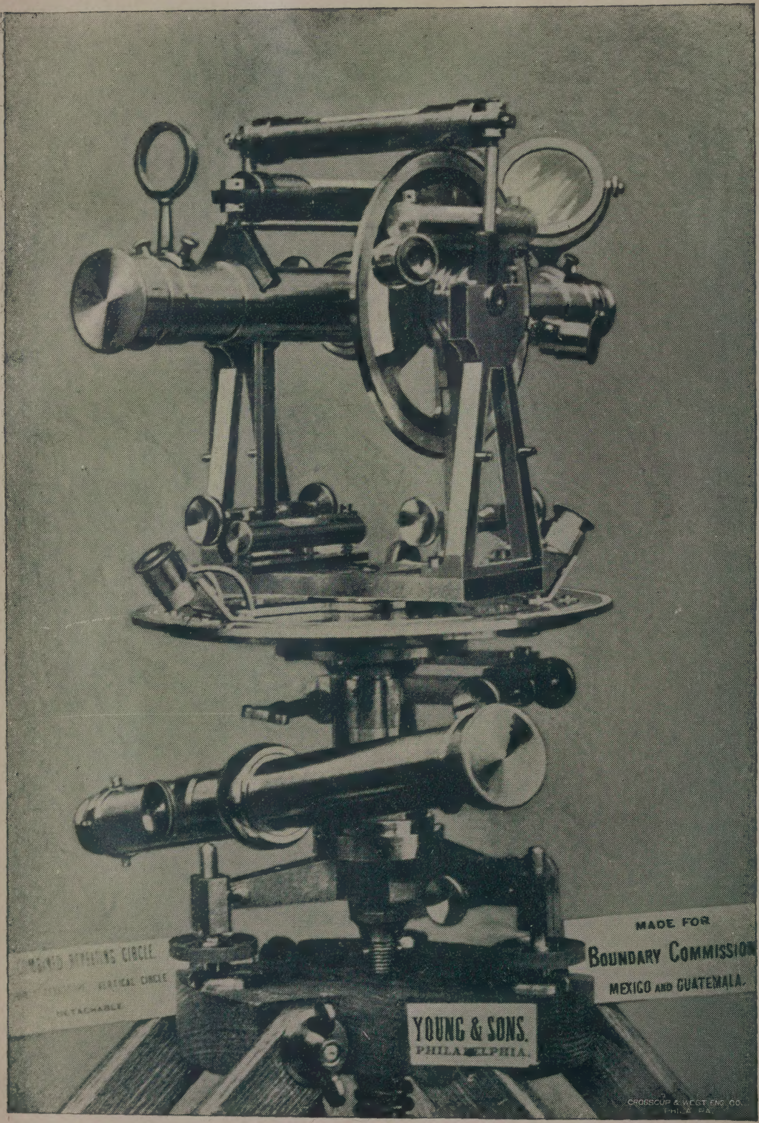

MADE FOR
BOUNDARY COMMISSION
MEXICO AND GUATEMALA.
YOUNG & SONS.
CROSSCUP & WEST ENG. CO.
PHILA. PA.

PREFACE TO SEVENTEENTH EDITION.

TO our Friends and Customers who have so generously favored us with their orders in the past, but have not perhaps kept track of the many improvements placed upon our instruments and our facilities to meet the wants of the Engineering Profession, with the opening of the new Century, we desire to call attention to our

Designs,

Graduations,

Choice of Selection,

Improvements.

At the World's Fair in Chicago, we were the only house awarded Medal and Diploma for

DESIGN AND GRADUATION.

Award reading "Uniform excellence in Design and Workmanship and Accuracy of Graduation."

DESIGN.—In designing our instruments, we have always kept in view that

Fewness of Parts,

Rigidness in the Wind, and the

Equal Contraction and Expansion of

working parts in all climates,

were the prime requisites for Engineering Instruments.

GRADUATIONS.—Under no circumstances whatever do we use **Cast Plates** for graduated horizontal circles of our Transits, but always "**hard-rolled and trip-hammered plates**;" thereby obtaining a **uniform density** rivaling that of silver. When graduations on solid silver are desired, the silver is inserted in these plates.

Recognizing the fact that **graduations** were the most important part of all **angular measuring instruments,** no time, labor or expense have been spared in order to stand pre-eminent in this line. Our two large automatic dividing Engines were **designed and constructed** in our own establishment and years were spent in **perfecting** them, and we claim our labor has been rewarded and there is not their equal in the country. Engineers are invited to call and inspect these engines.

It gives us much pleasure to state that we have about perfected our New **Goniometer or Triangulating Instrument.** Correspondence with those interested is solicited.

CHOICE OF SELECTION.

We offer the largest selection of Instruments for

Railway and General Practice,

City and Bridge Work,

Tunnel and Straight Line,

Triangulating,

Mining Transits in six styles,

Solar Compasses, Solar Transits,

Plane Tables and

Levels in Large Variety,

all designed and constructed to obtain best results with accuracy and speed.

IMPROVEMENTS.

TELESCOPES.—The glasses for our telescopes are made by the most celebrated opticians, who are well skilled in their art and who have our standing order to send us only the best, regardless of price, and we are enabled to place upon our instruments telescopes which, for Definition, Power and Field are superior to any heretofore made. By means of a recent improvement all fretting of the object slide is brought to a minimum, while with our NON-EXTENSION TELESCOPE, always in **perfect balance,** the object glass of which is stationary and the telescope at all times completely closed so that **dust and foreign matter is totally excluded,** the wearing of the object slide is entirely removed.

SHORT FOCUS.—By a change in the mechanism of construction we are now able to focus telescopes on very short distances—within **four or five feet,** without any additional parts and without any impairment of the

light or definition. Engineers working in Mines, Sewers or Tunnels will not fail to appreciate this small but useful improvement. We are also prepared to furnish a Bracket (a German idea) for setting up the Transit and Levels on the timbers or wall of a mine or in any confined position where it is impossible or inadvisable to use a tripod.

VERNIER READING.—The personal error arising from the improper position of the eye in reading verniers, called the **error of the parallax,** is by our improvement **entirely eliminated.** The eye taking the correct position **with certainty** and **without effort,** and furthermore this invention enables better results to be obtained with an ordinary size Transit provided with this improvement than could be obtained by a larger and heavier instrument without it.

POSITION OF VERNIERS.—It should not be necessary to state that we are following our **usual** custom of the last fifty years in placing the Verniers of our Transits at 45° to the line of sight, but the frantic efforts of some of our competitors to persuade the Engineering Profession that this is something new about an Engineer's Transit, we trust, will be sufficient excuse for having mentioned it.

MINING.—In Mining Transits we offer a selection unequaled, having five different designs, four of which are made in two sizes and in combinations, giving an Engineer not less than **fifteen Mining Transits to select from.**

All Auxiliary Telescopes are made in our **non-extension** pattern, insuring an equal balance in all positions.

Our Auxiliary Top Telescope is positively in line with Main Telescope when attached, and has no unsightly and cumbersome attachments to the Transit when **not in use.**

Our Auxiliary Side Telescope is provided with latest approved design.

The No. 4 Mining Transit is the widely known **Inclined Standard,** standing alone as the only instrument of its kind that has stood the test of time, in which the telescope can be ranged in a **Vertical line.**

SOLARS.—In Solar Compasses we offer the justly celebrated Burt pattern, as well as our own with the Smith Attachment attached in Burt's form.

In Transits, the Smith Attachment on the left standard with independent Latitude Arc is separate and distinct from the Transit, and the ordinary

workings of the instrument itself are in nowise interfered with,—is decidedly preferable for U. S. Deputy Surveyor work, but where only occasional use of the Solar attachment is desired it is sometimes placed upon the telescope.

LEVELING INSTRUMENTS.—In Leveling Instruments we have four different sizes, all designed in proportion to the **proper weight for the size.**

The Collars on the telescope are made of the **hardest bell metal,** and special attention is given to the **level vial.** The centers are made extra long to insure stability, and of metal to obtain the **least possible amount of friction;** and results obtained, we believe, equal to that of steel without any of its objections.

Our friends favoring us with their orders can rest assured they will receive instruments **replete with every modern improvement,** made in the **latest approved designs,** in the **best possible manner,** and the high reputation of our goods, sustained for over three-quarters of a century, will be strictly **maintained.**

Soliciting orders, we remain,

Respectfully,

YOUNG & SONS,

MANUFACTURERS OF

ENGINEERING, MINING, AND SURVEYING INSTRUMENTS,

No. 43 NORTH SEVENTH STREET,
PHILADELPHIA.

ESTABLISHED 1820.

CATALOGUE MAILED UPON APPLICATION.

W. U. T. CODE USED.
Cable Address, "Youngsons."

ENGINEERING AND OTHER INSTRUMENTS OF PRECISION.

The instrumental work required by engineers, more especially for use in mining interests, where the results of scientific knowledge and skill must be accurate underground as well as on the surface, is more varied and numerous to-day than a few years ago. Now, the question of transportation must be considered as well as the question of precise results, and the most perfect and delicate instruments are necessitated; from this necessity has arisen the extraordinary progress made in this country in the production of the various scientific appliances, and we are now in advance of Europe in perfection of instruments of precision. In the early history of Philadelphia are found the names of Godfrey, inventor of the quadrant; Franklin, Fitch, Evans, and other skillful mechanics, engaged in the invention and construction of scientific instruments; Rittenhouse made the first telescope in this country, and in the museums of the American Philosophical Society and Franklin Institute may be seen models of works showing the highest mechanical and mathematical genius, serving as incentives in improvements by the later generations. That worthy successors of those time-honored mechanics continued among us, to add to the scientific wealth and reputation of Philadelphia and this country, by their constructive skill, has an interesting and valuable illustration in the production of the house of Young & Sons, 43 North Seventh Street. This firm is the oldest, largest, and most widely known manufacturers of the finer kinds of mathematical, astronomical, and civil engineering instruments in the United States. The business has continued in the same family for three generations, the founder being the late William J. Young, who established the works in 1820, and carried it on for fifty years, when, at his death, in 1870, the business passed to his son, Alfred Young, the latter being succeeded at his death, in March, 1882, by his son, Alfred C. Young, who now conducts it, assisted by valuable skilled mechanics, one of whom has been connected with the house for forty-three years. William J. Young invented the transit instrument in 1831, a long stride in the improvement of engineering appliances; and that it retains today its almost identical first form, proves the value of its introduction and the good judgment of the inventor. The English Theodolite, capable of performing the same work, was not in favor with the earlier American engineers, its workings being slow and inconvenient, and its use attended with many discomforts.

Messrs. Youngs' Mining Transits differ from ordinary ones, principally in being of smaller size for greater portability, in having telescopes admitting more light and completely enclosed, having a greater range of vertical

angle, in the vernier and needle being more accessible to read, improved vernier, giving greater accuracy of readings, and its position to one side of the standards very preferable where the engineer is working in confined situations; a *Gradienter Attachment* measures (where the grade is not too steep) the inclination with *accuracy and speed*, besides distances and differences of level. Messrs. Young lately built a *Graduating Engine* costing $7,000, and four years were occupied by three of their best workmen in testing and correcting it, that it might be, as intended, a manual of precise scientific mechanism, and enable them to guarantee their astronomical instruments as the finest work of the class produced in this country, and equal to the best European work; instruments with circles as large as forty-four inches can be graduated on their engines. In their line of manufactures, Young & Sons admittedly lead the trade in the United States, and with confidence in their superiority, can request the attention of colleges, institutions of learning, civil and mining engineers, and private parties to their facilities and ability to produce perfect work in their specialties.

—Balch Mining Interests of the United States.

GRADUATING ROOM—YOUNG & SONS.

PRICE LIST

OF

Engineering, Mining and Surveying

INSTRUMENTS,

MANUFACTURED BY

YOUNG & SONS,

INVENTORS AND INTRODUCERS OF

ENGINEERS TRANSIT,

No. 43 NORTH SEVENTH STREET,

PHILADELPHIA.

INCLUDING

AN ACCOUNT OF INVENTION AND INTRODUCTION OF

ENGINEERS' TRANSIT.

Money must accompany the order when no Philadelphia or New York reference is given.

Remittances may be made by bank-draft or Post-Office Order, made payable to us,—or if preferred, goods will be sent C. O. D., provided order is accompanied by a remittance of Five (5) Dollars, and when west of the Mississippi by Ten (10) Dollars. The object of this is to insure the goods being taken, we frequently having sent goods by express which were not taken by consignee, and have been compelled to pay express charges both ways.

The prices quoted are those at our establishment. When boxing is needed, the actual cost of boxes is charged. When boxed by us we guarantee the safe arrival in good condition of the instruments to any part of the country, except under extra hazardous circumstances.

All express charges and charges for collection are to be paid by the purchaser.

On orders for *Engineering* instruments, accompanied by draft to amount of catalogue price, no charge is made for boxing, purchaser saving the cost of boxing and collection.

All instruments made by us are guaranteed to be of most skillful workmanship, most accurate construction, and of very best materials. The guarantee is not limited to any time.

Instruments will be sent C. O. D. with privilege of five (5) days trial when satisfactory reference is given.

Many small articles such as Chains, Tapes, Drawing Instruments, &c., when not weighing over four pounds can be sent by mail.

In all cases where goods are to be sent by mail, the cash for postage as well as the goods must accompany the order.

THREE-QUARTERS OF A CENTURY our establishment has been engaged in the manufacture of Mathematical, Engineering and Astronomical Instruments.

For the character of our work we make but one reference—the number of our instruments throughout the country, the number of years they have been in use, and the reputation they have maintained during that time. Some of these instruments, made over fifty years since, are yet in active service, doing accurate work, while cheaper instruments are being discarded after from three to four years' work.

We refer, with pride, to the introduction, by us, of the Engineer's Transit, both in its original form, and in the subsequent styles as made by us. In the earlier days of railroad construction, when transportation was slow and difficult, requiring months for an instrument to reach its destination or to be received back from instrument maker in case of repairs, our Transit was strong, simple, substantial, almost impossible to be placed out of repair. Our later instruments are replete with every modern improvement, capable of the most delicate and accurate work. From the earliest to the present time, the superiority of these instruments has been unquestioned.

Our experience has led us to produce several improvements, amongst others Gradienter, the Slide Protector, Eye Piece, Tangent, Fastening of Level Telescope, Improvement in Opposing Pieces, Improvement for Obviating Error of Parallax, as well as improvements on various minor points. Our self-reading Level Rod, introduced by us twenty-two years ago, is fast superseding all other styles, and the use of other rods, except on special cases, is abandoned by those who have once tried this form.

The materials in our instruments, our style and modes of manufacture, have been adopted after trial and test, during past fifty years, of all others, and our patrons may confidently rely that the various new materials and new constructions, blazoned forth periodically, have been tried, tested and discarded by us.

The graduations, the main point of all angular instruments, are, in our instruments, performed under our personal inspection, upon a

line of graduating engines, superior to all others in the country. So acknowledged is this superiority, that no establishment but ourselves has attempted the manufacture of finer astronomical instruments calling for graduations of larger circles.

Making no pretensions for sale of low priced instruments, we require only such prices as will enable us to produce good instruments, and these prices will be found, for similar instruments, not exceeding those received twenty years ago.

Having endeavored, by more perfect system and increased facilities, to counteract the increased (in some cases almost doubled) cost of skilled labor, a fair comparison, including many minor points of improvements, not so evident but of cost in construction, will show prices of present less than those of past; and as it is upon the standing and character alone of the manufacturer that the purchaser must rely, we feel confident our friends have no just cause of complaint.

YOUNG & SONS.

Care of Instruments.

It is highly important the Engineer should understand those points in the care of an instrument, by which he can preserve its usefulness, or temporarily supply any small deficiency.

In the ordinary Compass the main point is to avoid dulling the centre pin. If point is soft, this dulling will occur from natural weight of needle. If the point is hardened carefully it will last, as far as effects of wear are concerned, many years. To preserve the point avoid all sudden jarring and jolting when needle is down, as the harder and more perfect the point the more subject to breakage from this cause. Never lift the instrument without being sure the needle is screwed up. Should the point become dull, use a small oil stone, holding it against the point, and sharpen, if possible, by revolving instrument on its centre while stone is moved slightly along. If instrument cannot be revolved so as to make centre pin revolve, sharpen by pressing stone against point and moving it in a circular direction. Do not use stone in a straight line, as then, in place of a round point, there will be one with many sides, as it were, and it will be impossible for needle to play freely.

This method will not produce a perfectly shaped point, and will only answer as a temporary relief.

The shape of centre pin should be so as to form an angle of say 15 to 20 degrees at point, keeping the upper part straight, not curved, so that on a little wear the thickness of point, if we may so speak, will not be so much greater. A dulling of point from wearing or breakage causes friction by its edges bearing against side of cap, and is the *principal* and almost universal cause of failure of needle to play freely. A *perfect* point is of greatest importance, and can only be relied upon at the instrument makers.

The height of centre pin is of consequence as affecting the ends of needle. When the centre pin, which is the same as bottom of cap centre, and the ends of needle, are of same height, the "trembling" of the needle produces no motion on its ends, and if these are on a level with top of ring parallax in reading of needle is avoided. It is preferable to have the ends of needle a trifle above the ring: breakage of point or constant sharpening of pin brings point much too low, when the only remedy is a new centre pin.

Should the North end of needle become lower than the South end, the balance should be restored by sliding the brass wire on South end.

With the cap to needle the Engineer can do but little. Its shape is such that it forms a centre and nothing more, so that point rests nearly on a plane. Any attempt to smooth the cap is likely to result in destroying this form, either producing a plane surface, where the needle finds no centre and will rest on no particular point, or producing an angle, the sides of which will bind on sides of point of centre pin.

A good needle, of proper materials, and properly charged in first place, does not often lose its magnetism. It may be, when power has gone, assisted by magnetising with a good horse-shoe magnet; but it is best not to use the magnet unless its comparative power is greater than the needle. It is an accepted theory that the needle will retain its magnetism more perfectly when allowed to lie in meridian, and for this reason it is advisable, when placed away for a long time, to allow needle to rest upon centre pin and take its natural bearing.

Object and eye glasses of telescope should be kept clean of dust, and especially grease, or anything that will form a film over glass. Small particles of dirt upon object glass are not so bad as a thin imperceptible spot of grease, &c. Wipe with a soft, well used rag,—not with silk or piece of new muslin. It is very seldom necessary to wipe the inside of glasses that are protected.

The glass next to the eye, especially in high powers, frequently becomes dimmed from moisture of eye lash. This should especially be regarded.

The object glass should not be unnecessarily unscrewed. It destroys adjustment of collimation.

The CROSS HAIR SCREWS should be used carefully, the great tendency being to overstrain them. In adjustment, be sure they come to a fair bearing with each screw; nothing more than this is necessary. Unloosen the screw on one side before tightening the other, and in erect eye pieces remember the real motion is opposite the apparent. Forgetfulness on this point is frequent source of trouble. Straining these screws is more apt to cause instrument to lose than retain adjustment.

Should any little dust alight upon cross web, it may frequently be removed by taking out eye piece or object glass and blowing gently through tube; but unless on such part of web as to interfere with use it is preferable to allow it to remain.

The TELESCOPE BEARING should be so firm as not to allow shake, but nothing more,—the friction of this will keep telescope in position. The screws which confine these bearings should often be looked to.

The telescope slide should be watched that it has no shake. If not protected by our dust protector, the slide should often be wiped. Should the slide commence to fret and grind, take it out at once, and first scrape, then burnish down the place where it has fretted. The blade of a penknife forms a very good instrument for this purpose, scraping off with edge slightly inclined, and burnishing with back of knife. Wipe out inside of tube, and if possible burnish and scrape that smooth. Grease the slide slightly, and wipe off grease before restoring it to its place. Too much grease causes dust to adhere. Do not use any *emery* or emery paper to repair slide,—it will be a continual source of trouble afterwards. A slight grinding with pumice stone dust, fine and without grit, and a little oil, may be of service, but should be carefully done, or is best left to instrument maker.

Fretting of centres should be treated the same way as of the slide to telescope. It is advisable, if instrument shows any sign of working hard, to take out centres, wipe them, and replace with fresh grease; but so long as centres work free, it is best not to disturb them.

It is not to be expected the Engineer will be able to repair this injury; but where fretting once commences the tendency is to become worse very rapidly, and a few moments use may destroy the slides or centres so they cannot be repaired, and unless necessity compels its continued use it is best to stop at once.

Should the fretting be in the centres, and the above means not remove it entirely, a temporary relief may be found on placing between the shoulders of the centres a washer of paper or thin card. There will then be a shake in the centre, which, however, will be a lesser evil than entire loss of use of inst ument.

The best grease is good marrow, rendered. Most oils, notwithstanding their claimed qualities, gum, and become an injury to the instrument, causing it to work hard, sometimes so hard as to render instrument useless.

Fretting of parallel plate or levelling screws can best be avoided by taking out screws, washing them with soap and water by a brush, screwing a piece of soft wood, with two sides thinned down, through the nut to clean it, and replacing screw, greasing slightly.

Tangent and clamp screw fastenings should especially be examined from time to time, that they do not become loose, allowing play in reversing instrument.

The tripod legs should have no looseness in fastening of shoes, or where the legs fit in tripod. The small screws which hold the cheeks of tripod head to the plate should be examined to see if tight. No instrument will be firm if any shake exists in fitting of legs or in shoes. It is important that the points of tripod shoes should be somewhat sharp, sufficiently so to take hold on any surface when set up. The greater the hold of shoes in ground, the steadier the instrument. Without this hold there is only the weight of instrument to resist any force, either direct or resultant, in upward direction.

In the use of all screws, bring them to a firm bearing, but do not overstrain them. Either the thread stretches and wears rapidly, or some part of instrument gives way, and eventually becomes loose by overstraining.

Moisture on glasses, either telescope, compass or vernier, can best be removed by placing instrument in a dry, moderately warm room. If time cannot be spared for this, wipe off dry, but while doing so, and in replacing them, be careful no dust or dirt gets in the instrument. In cleaning object glass, dirt is apt to fall into tube, and afterwards fall upon cross web. In cleaning vernier, dirt is apt to get between vernier and plate, bruising graduations; and in cleaning of compass ring, a small ravelling of thread or lint, invisible to the naked eye, will sometimes adhere to side of ring, and prevent needle from playing. This last is frequently the cause of serious errors.

It is not advisable to take instruments apart unnecessarily. Very slight disturbances are often productive of great injury. Even where fittings are perfect it requires care and experience to place them properly together. A screw left loose, or one tightened too hard, may interfere with correct working of instrument.

Repairs to Instruments.

Repairs to instruments injured by accident are generally more serious than the Engineer supposes, and usually the cost of these repairs exceeds the anticipated amount. There are several reasons for this. Breakage of parts is evident to the Engineer, and he generally attributes the whole cost of repairs to this alone, whereas these evident breaks form the lesser portion of cost, the greater cost being in points only developed by more critical examination, and of which he has no idea. None but those familiar with repairing can realize the time consumed in removing what appears a trivial fault, but which the correct working of instrument requires to be thoroughly eradicated. When we consider the severe tests to which the various fittings of the instrument are subjected, by means of the graduations, of the level, and of the telescope, the necessity for repair, as near perfection as possible, regardless of time consumed, becomes evident, and the cost of these repairs explained. What may be termed, in contradistinction to the Engineer's adjustment, the Instrument Maker's adjustment, which consists in placing all parts of the instrument correctly together, so as to work smoothly, detecting any points which may be wrong, seeing that no part is strained, that the needle, verniers and plates are properly centered, &c., cannot be conscientiously and well performed in the Transit under a cost of $10.00; in a Level under $5.00; and Compass under $3.00. These are independent of cost of repairs, which are charged according to time consumed.

In course of repairs, points of injury not apparent to the Engineer develope themselves, and those which appeared trifling, because of their minor importance, become serious when the more prominent are corrected; so that it happens that instruments are frequently sent to be repaired at certain points, and yet when these points are repaired, the instrument is almost, if not quite, as useless as before. We have adopted, as our rule, to thoroughly examine and repair every instrument sent, believing it most satisfactory and economical to the Engineer, and feeling assured the result is in all cases beneficial and in end satisfactory.

Transit.—This instrument, from its being the most complicate, is the most costly to repair, nearly every part being liable to injury from a fall. Injuries to standards can generally be repaired, though where great it is generally best to replace with new, as much time may be wasted ineffectually in endeavoring to bring bearings correct.

Bending of plates from a fall, if the metal is rolled brass, can be remedied, unless the bend is "short," and severe. Where metal is cast brass a complete turning and re-graduation is generally found necessary.

Where slides of telescope are much injured by fretting, or by a fall, or by wear, a new slide is advisable as the only efficient remedy. A speedy method of closing tubes gives appearance of repairs, and though difference

is not evident to Engineer, the telescope soon becomes as bad as before, and the slide will not project on true line of collimation.

Where centres or plates are injured, the cost of repairing this part, if a flat centered instrument, is about $5.co; if a long centered instrument, ranges from $10.00 to $40.00. Injury to telescope is serious, from difficulty of causing them to work on line of collimation.

As a general rule, the cost to repairs to transit, even if injury is slight, will vary from $7.00 to $12.00; and if serious, such as from a fall, will vary, if a flat centre instrument, $15.00 to $30.00, and a long centre, $15.00 to $60.00.

Re-graduations of our graduating engine costs $15 00.

LEVEL repairs vary from $6.00 to $12.00, unless new centres should be required, or heavy repairs to telescope, when the cost may extend to $25.00 or $30.00.

COMPASSES are principally injured by dulling of centre pin, bending of plates and sights.

Cost of re-adjustment of needle, and re-magnetizing same, is $3.00. New centre pin, $1.00; cap and needle, new needle seldom wanted, $4.50; new cap to needle, $2.25; new glass, best French plate, $1.00.

Repairs to Solar Compasses are especially expensive. The extreme accuracy necessary in principal parts of this instrument to a correct working, and the time consumed in instrument maker's adjustment and examination, bring the repairs to this instrument from $20.co to $60.co.

We have intended these remarks to furnish a general idea to those of our friends who are inquiring of us the cost of repairs; but we would impress upon them what they expect their instrument to be and to do after repairs, and recall what we have said in reference to "instrument maker's adjustment." It is not unfrequent that when we suppose the repairs and adjustment almost finished we discover some point needing attention, which, though the consequences may be trivial, needs attention, and may possibly require as much time as the greater repairs.

☞ Instruments sent for repairs should be carefully packed. They are at times much injured in coming to us for want of this care.

Place in box address of party sending, and memoranda of points which Engineer considers require attention, though not necessary, may be of advantage. It is advisable to place our name in full; but "Young, Instrument Maker, Philadelphia," will secure safe arrival.

Tripods need not be sent, unless of a special pattern.

Always send the "Ball-Spindal" with Compasses.

Engineering Instruments.

The various improvements we have added to our Instruments during past few years, have, in instances, so changed their characteristics, that our older friends and correspondents may not be familiar with them. To those desiring any particular instrument, we will mail photographs, an examination of which will afford correct idea of the improvements and details.

These improvements have for their purpose increased accuracy, and we believe have in all cases added to efficiency of instrument; but there may be circumstances, such as railway work in rough country, and in places distant from repairing facilities, where one great characteristic of our older instruments, viz., their great endurance of rough usage, may counterbalance the benefits of the additions. For this reason we still continue to manufacture our older styles as heretofore.

The telescopes, as placed upon our instruments of four or five years past, have a much higher power than heretofore, and while this high power is extremely desirable in many respects, it is necessarily accompanied in all cases by loss of light, a smaller field, more wear upon slides of telescope, a greater difficulty in focusing an object, requiring more time to work, and a greater liability to error if not properly focussed.

We advise our friends of those differences, that they act understandingly in their choice of instruments, and select those most suited to their purposes.

Graduations being the really important part of an angular instrument, such as Transit, we have devoted especial attention, to enable us to stand pre-eminent in this one point. We believe our expenditures in this line have nearly equalled the combined expenditures of all the other instrument makers, while our line of engines has enabled us to complete work not attempted in any other establishment. Our

friends may rely upon the work being done under our personal supervision, the facilities in our Automaton Engines enabling us to allow sufficient time in process of graduation to ensure best results; while, to avoid the unsatisfactory work arising from too common error of speedy graduation, we occupy from two to four times as long in the process as is generally occupied by others.

Experience has shown us the materials upon which graduations of our ordinary Transits are made, being brass ROLLED especially for us, and condensed under our trip hammer, especially adapted for the purpose, obtains a uniform density rivalling that of silver, and a hardness much to be desired. The porous nature of all castings, excepting, perhaps, yellow brass, which can be hammered and condensed, has compelled the adoption, in larger instruments, of silver or other homogeneous metals. The small air holes, and deficiencies of castings, causing the point of cutter to deviate from proper place, producing unequal spaces and unequal thickness to lines. This is one reason we avoid castings for our graduated plates of best instruments. The silver has very serious objection, that though alloyed, it is so soft that the least particle of dust or dirt between verniers and plates turns up edges of graduations, destroying their accuracy, in many cases obliterating graduations at the edge.

We consider that, for fine graduations, such as under twenty seconds, silver is best material, principally on account of surface requiring no working after graduations, to endanger obliteration of fine lines; but that for graduations of one minute, or even to twenty seconds, our rolled condensed brass is preferable.

The centres and all bearing parts of our instruments are made of a bell-metal manufactured especially for us.

Selection of Instruments.

The grades of instrumental work now called for from Engineers being more numerous and varied than formerly, extending from that calling for most accurate results necessitating the most perfect and delicate instruments, to that where the question of results is to be considered along with the question of transportation, has called for a greater variety of instruments than heretofore.

While instruments of medium size and weight have a wide range of adaptability, we have found it impossible to supply the different requisites in the most satisfactory manner in the same instrument. We have therefore adopted as the results of our experience a classification for Levels; Transits and other instruments, the basis of a heavy, medium and light instruments; for, though accuracy by no means follows as a certain result of weight, it is certainly true that weight limits size, and with same skill in proportioning size limits accuracy. The character of the work is the same in all our instruments,—the higher priced ones, in addition to size, have principally small additions to increase their efficiency, and such modification of construction to adapt them to their purposes.

TRANSIT No. 6.—For Railroad work.
For City and Town work.
For General Practice.

TRANSIT No. 7.—For Special City and Bridge work.

TRANSIT No. 10.—For Mountain Work.

TRANSIT No. 13.—For Straight Line work in Cities and Tunnels.

TRANSIT No. 3.—Is our celebrated Transit we have made for over half a century, with modern improvements, including long centres, and is recommended for work of ordinary accuracy.

With the addition of a Variation Plate, it becomes a Surveyor's Transit.

No. 10 MOUNTAIN SOLAR TRANSIT.—Is recommended to U. S. Deputy Surveyors and others desiring an instrument with a Solar attachment, as it has three distinct advantages over any other yet offered:

1st. Its extreme accuracy.

2nd. The working parts of the Solar attachment are not disturbed, when instrument itself is used as a Transit.

3rd. It can be used in cloudy or hazy weather, when other forms of Solars are useless.

MINING TRANSITS.—In Mining Transits, Nos. 1 to 5, we offer a selection not surpassed by any other house—all except No. 1 are made in two sizes. All are made with interchangeable Lamp-Targets, when so ordered.

No. 1. Is provided with Auxiliary *Side* Telescope, *attached* to large Vertical Circle, all detachable.

No. 2. Has Auxiliary *Top* Telescope, detachable with noted improvements.

No. 3. Has Auxiliary *Side* Telescope, detachable with noted improvements.

No. 4. Is our justly celebrated "Inclined Standard," standing pre-eminent as a Mining Transit.

No. 5. Is a Transit without Auxiliary Telescope, furnished with Arc or Circle, etc., as desired.

IMPROVEMENTS.

It is a gratification to us to be enabled to say to our friends, that not only is the invention and introduction of ENGINEER'S TRANSIT due to our house, but likewise, in our belief, we are justly entitled to claim that every actual improvement, in either Transit or Level, as well as other instruments, have originated with us.

Gradienter.

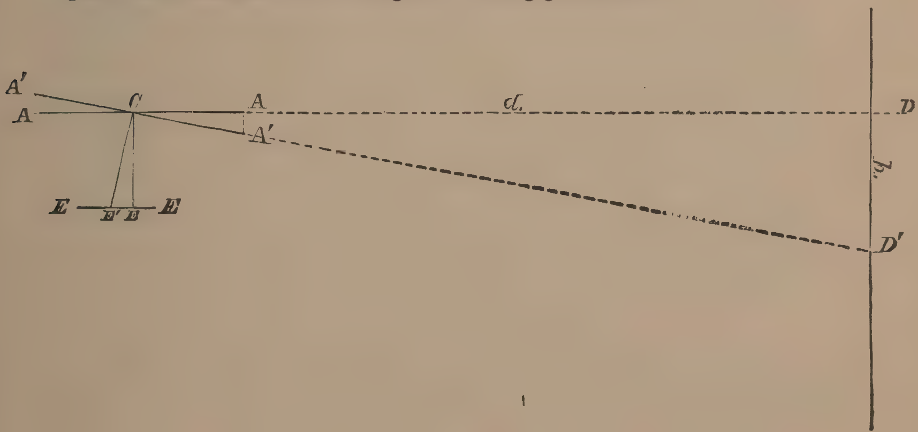
This important addition to our Transit instrument measures with accuracy, and economy of labor and time,

1st, Gradients,
2d, Distances,
3d, Actual differences of Level.

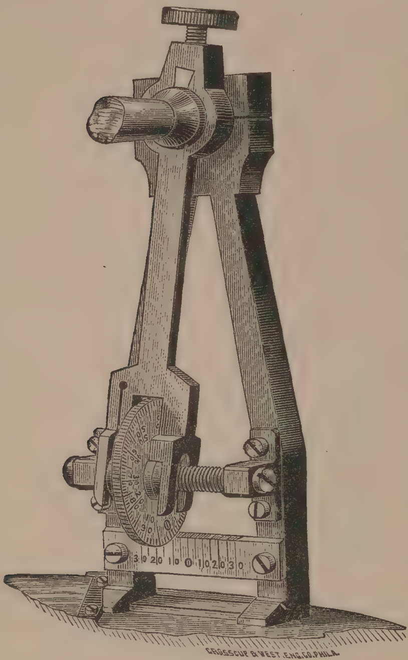
The ordinary Transit simply measures the angular position, as referred to a certain line; the Gradienter addition determines every other condition necessary to establishing the actual position of any point.

The addition adds very little to weight of plain instrument—nothing whatever where level is already placed on, and its peculiar advantage consists in no manner interfering with the use of instrument as a Transit.

In its construction, a clamping arm extends downwards from axle upon which telescope revolves, and is forked at lower extremity to embrace a micrometer headed nut. This nut moves along a screw, accurately cut upon our straight line engine, making a certain number of revolutions to the hundredth of a foot. The head of screw is graduated into one hundred parts, and attached is a zero edge for reading graduations.



If the line A A represents the centre line or optical axis of telescope, when level, and which produced strikes a rod at D; C E, the perpendicular or clamp piece of Gradienter; and E E the micrometer screw parallel to telescope or A D:—then, when we clamp Gradienter, and move the micrometer screw along E E, the telescope and its produced line will also move the same angular distance, the produced line striking at D′.


THE GRADIENTER.

It is evident that C E E′ and C D D′ are similar triangles, and if we know positive values on one, and relative values of both, we can determine other values.

Thus, if one revolution of micrometer screw moves Gradienter with a proportion of one foot perpendicular to one hundred feet horizontal, then the telescope would be elevated (or depressed) as to indicate a difference of one foot on D D′ placed one hundred feet off; and two revolutions indicate an elevation or depression of two feet in the hundred feet. Hence, the number of revolutions, and parts of a revolution, as indicated by graduations on the screw head, measures the grade from the level,—not in *terms of arc*, but in measures of base.

As the proportion of screw is such that a full revolution gives one foot vertical in a distance of 100 feet horizontal, when the motion of telescope measures this foot, it necessarily follows the rod must be 100 feet distant; or if telescope measures 1.50 feet, the rod must be 150 feet distant.

Or if points D D′ are at a fixed distance from each other, so as to form a base, and the Gradienter is moved that the micrometer head travels as to bring line of sight from D to D′, then is given the similar sides D D′ and E E′, and their proportional value to other sides, from which C D or distance is known.

It will thus be seen how simple are the principles upon which Gradienter depends. For its use, we give following simple

DIRECTIONS

where the screw and micrometer head are so arranged as one full revolution, or 100 graduations gives proportion of one foot vertical to 100 feet horizontal.

TO RUN A CERTAIN GRADIENT.

Bring Telescope level by means of milled head; then noting reading, continue motion of milled head one revolution and part thereof for each foot and part thereof, of foot per hundred of your desired gradient.

Thus to set off gradient of 0.5 foot per 100 feet, move micrometer milled head 50 graduations from the level.

To set off 2.25 foot per 100 feet, move 2 revolutions and 25 graduations.

TO MEASURE A GRADIENT.

Bring telescope level, and note reading as before; then turn micrometer head until telescope line strikes the target or other object; the number of revolutions, and parts of a revolution, indicate the feet and parts of feet per hundred of gradient.

THUS 1.40, or 1 revolution and 40 graduations, indicate 1.40 foot per 100 feet; 2.50, or 2 revolutions and 50 graduations, indicate 2.50 foot per 100 feet.

TO MEASURE DISTANCES.

Performed by two methods.

1st, By use of usual graduated rod. *By noting distances on rod graduated in usual style, passed over by one revolution of micrometer head.*

THUS, if one revolution of micrometer head passes the reading by the cross web of telescope from 5.00 ft. to 6.27—difference 1.27, the distance is 127 feet; if from 4.50 to 6.78—difference 2.28, distance 228 feet.

It is not necessary the operation should be confined to a single revolution of head, but there may be made as many as desirable. Thus, as above, the first reading 5.00, 3 revolutions give 8.81—difference 3.81; divided by 3, number of revolutions, 127. Again, first reading 4.50, 2 revolutions give 9.06—difference 5.56; divided by 2, number of revolutions, 228 feet.

2d, By having an ascertained base, as two targets or other marks placed upon a rod, at any desired distance apart. *Bring telescope on one target or mark, note reading, and turn micrometer head until it strikes other; the difference in readings or number of graduations passed over by micrometer head, divided into base and multiplied by 100, gives distance.*

If in previous figures we denote D D′, on this case, our base by b; C D the distance by d; number of graduations passed over by n; then we obtain as formula, $d=\frac{b}{n}$;

or, DISTANCE EQUALS BASE, DIVIDED BY NUMBER OF GRADUATIONS.

As the graduations are hundredths of a whole revolution, it is necessary to multiply result by 100 to bring it to feet.

THUS, targets are placed 6 feet apart, number of graduations passed over are 250, or 2 revolutions, 50 graduations; then

$$\tfrac{600}{250} = 2.40 \times 100 = 240 \text{ feet.}$$

Targets 8 feet apart, graduations 315,

$$\tfrac{800}{315} = 2.539 \times 100 = 253.9 \text{ feet.}$$

The advantages of this last method consists,

1st, In the sights being taken on targets or other prominent marks, more plainly visible than figures or graduations on a rod, by which means a distance of at least three times as great can be taken as where it is necessary to read the figures; or same distance can be taken (except short distances, where figures are *very* distinct,) with three times the comparative accuracy.

2d, The base can be changed as desired, and made to suit the nature of work and character of ground.

It is not necessary in this method to use a graduated rod; any two marks at ascertained distance apart answer equally as well.

In previous description we have supposed the fineness of screw to be such as to give a ratio of one foot vertical to 100 feet horizontal. We have deemed it preferable, in our larger instruments, to make screw finer, as giving more sensitive motion, and have made it to have ratio of 0.5 foot vertical to 100 feet horizontal. The former rules should then be modified as follows:

TO RUN CERTAIN GRADIENT.

Turn micrometer head, double the number of graduations of micrometer head that is wanted in feet, per hundred.

Thus, wanted 1.7 ft. per 100, turn $1.7 \times 2 = 3.40$.

TO MEASURE A GRADIENT.

Divide the number of graduations of micrometer head by 2, to obtain ratio per hundred.

Thus, 280 graduations, $\frac{280}{2} = 1.40$ foot per 100.

TO MEASURE DISTANCES.

1st, By use of usual graduations on rod. *Move double number of revolutions.*

THUS, two revolutions give 2.60 on rod; distance equals 260 feet.

2d, By ascertained base.

Change formula into $d = \frac{2b}{n}$;

or DISTANCE EQUALS TWICE THE BASE, DIVIDED BY THE NUMBER OF GRADUATIONS.

THUS, base 6 feet, graduations 500; distance 240 feet.

In use of Gradienter, as in use of every instrument to which a screw movement is attached, it is preferable to set micrometer head somewhat back, and bring it up to readings in direction in which movement is to be made. Though, perhaps unnecessary, it is a precaution that is always advisable.

The utility of Gradienter in running of grades on rail-road or other work, or in measuring gradients on preliminary or location, are evident to any engineer.

To illustrate its benefits in a general way, suppose the engineer to desire a position of point, not only as regards alignment, but also as to distance, grade and difference of level.

He sends rodman to point, with target (fixed, if desired, at height of instrument), and with another target, or other plain mark, placed at, say 6 feet apart from first. He brings telescope level by micrometer head, and from this raises or depresses telescope, by micrometer, until it strikes first target. His readings then give him his gradient. He then makes a full revolution (or two or more if desired), and reads distance on his rods; or, he uses base on rod, and reads the number of graduations passed over, and thus obtains distance; or again, uses both methods, one to check other. Having distance and gradient, he multiplies them together, and obtains difference of level.

EXAMPLE.—Suppose, with screw giving ratio of 1 vertical to 100 horizontal, the observations are:

	From level he depresses . .	283 graduations.
	1 turn of screw gives . . .	310 feet on rod.
	Motion over base of 6 feet gives .	193 graduations.
	Then, 1.92, divided into 6, gives .	310.1.
Results,	therefore, gradient, . . .	2.83 ft. per 100 ft.
	Distance, ...	310 ft. by reading.
	Or more accurate by base, . .	310.1.
	Difference of level, 2.83 $\times$ 310 .	8.773.

With screw giving ratio of 0.5 ft. per 100 feet, the observations would have been:

From level, grade . . .	5.66 graduations.
2 turns of screw give . . .	310 ft. on rod.
And base 6 feet, ...	286 graduations.

No other instrument in practical use accomplishes the same results, viz., measurement of distances, grade and differences of level. For the measurement of distances we believe it preferable to the stadia wires. As a measure of comparison we generally place fixed stadia wires in telescope. As compared with stadia it has several advantages; the line of sight is in all cases directly in optical axis of telescope, being unaffected by want of flatness in the field, a source of inaccuracy and great objection to the stadia; the measurements are made from centre of instrument direct, while in stadia measurements it is claimed allowance must be made for focal distances.

A great advantage in favor of Gradienter lies in the inability to use ordinary stadia wires at a distance beyond where the figures on rod are plainly visible,—the setting of targets in use of stadia is so slow, and so difficult an operation, as to forbid its general use, while the reading of hundredths of a rod, at any great distance, is an impossibility. The Gradienter, on contrary, in use of base system, makes the sights to targets or other marks which can be made, as distinct as needed. Not only this, but the base on Gradienter can be altered—made large or small—to suit character of work desired.

That property of the Gradienter, by which all that is positively required for its use, is to know the simple distance of marks or targets apart, is

a remarkable illustration of merits of Gradienter. Using this distance as a base and measuring distance by micrometer screw,—WITHOUT USE OF GRADUATED ROD, with nothing but the knowledge of this distance of targets—then follows:

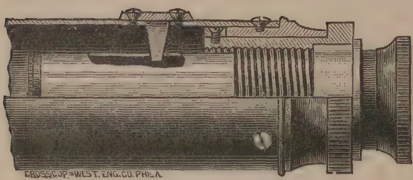
The measurement of Grade.
" " of Distance.
" " of difference of Level.

It is not even necessary to *know this distance at the time.* In case of emergency two marks may be placed upon a temporary rod, the observation made and distance of targets obtained afterwards.

The form of Gradienter, of German origin, where the micrometer screw is placed under the end of telescope, entirely prevents the use of instrument as a Transit, producing an instrument which the Engineers of this country look upon with especial disfavor.

With advantages enumerated, taken in connection with its adding nothing to weight or complexity of Transit with level to telescope, we fee confidence in recommending to favor of profession Young's Gradienter.

Eye Piece.*



EYE PIECE.

The Improved Eye Piece adjusts the focus to web with great precision and smoothness. It is so made that the eye piece does not turn as it moves out and back, but moves in same straight line, preventing rotation of eye piece upon image.

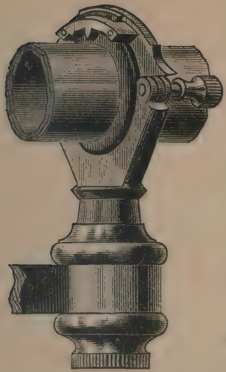
An incorrect focusing of eye piece produces parallax in sighting, throwing object to one side or other of web. An accurating focusing of eye piece is of as much importance as power of telescope; and as power increases it is the more difficult to focus with the usual slide—with extreme high power almost impossible—hence, importance of this improvement.

Improved Telescope or Web Fastener.

In the usual construction of the Level instrument, even when in perfect adjustment, an observation taken other than at immediate intersection of cross web, tends to produce error, from the rotation of telescope in Y bearings throwing all other parts of horizontal web above or below the true level line. The bringing to exact intersection on rod is tedious,—the examination

---

* The original adjustable eye piece we believe to have been made by Messrs. Kubler & Seelhorst. We believe our method to be an improvement.



WEB FASTENER.

and correction of horizontal web each time still more so; while, unless one of these are resorted to, error is almost certain, and this error is the great source of inaccuracies in operation of levelling.

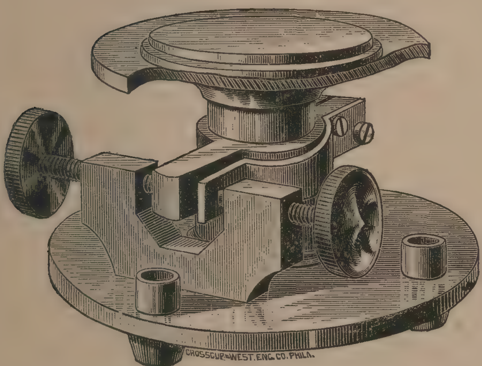
To obviate these errors, we fasten the telescope on the Y's so as to prevent any rotation. Observations can be made at any portion of the field of view, equally as well as the centre. Another advantage consists in the certainty with which the Engineer can regulate the perpendicularity of his rod.

The attachment interferes in no manner with adjustment of instrument. It has met with universal approbation wherever used.

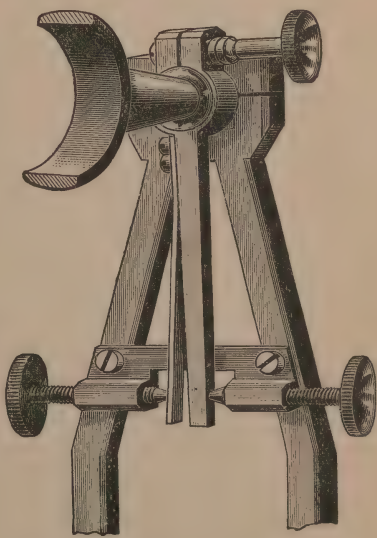
Opposing Piece.

Wherever the opposing piece is used we now attach a strong German-Silver spring, as shown in the engravings.

This spring has sufficient tension to keep the clamp firmly in position, and insures a steady movement while in use, *it being necessary to use only one of the opposing screws at a time.*

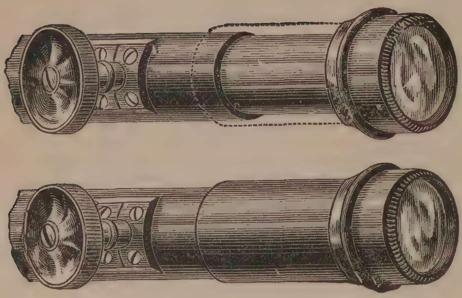


SHOWS CLAMP AND OPPOSING PIECE ATTACHED TO THE CENTRE OF TRANSIT.



SHOWS CLAMP AND OPPOSING PIECE ATTACHED TO THE AXIS OF TELESCOPE.

Slide Protector.



SLIDE PROTECTOR.

The motion of tube or slide of object glass upon main telescope tube is apt in time to wear, one or both sufficient to produce a shake, the result of which is to throw line of sight to one side or other in focusing the telescope. Inability to wear a long time without shake is a sign of a poorly constructed instrument; but even in best constructed the dirt, grit, &c., which adheres to slide and is carried into tube by it, is a cause of more rapid wearing, or a greater inconvenience at the time, be a fretting of the slides. Rain and moisture is also carried in making air inside of tube damp and affecting the performance of telescope.

As a preventive we have added our SLIDE PROTECTOR,—a thin tube or sleeve covering the slide and moving with it, so that neither dust nor dirt can reach it.

The attachment preserves the slide, upon which perfection of collimation depends, in good condition for a much longer time.

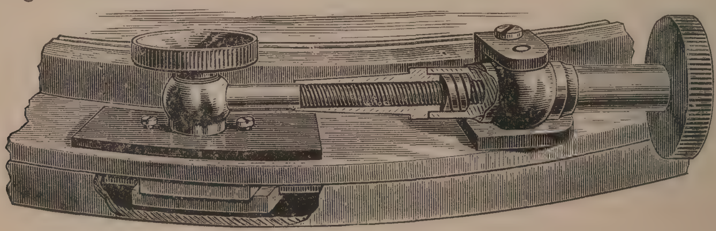
Tangent.

The Tangent with double nut, or a follower, and spring between the two in such manner as to keep them apart, is an English invention.

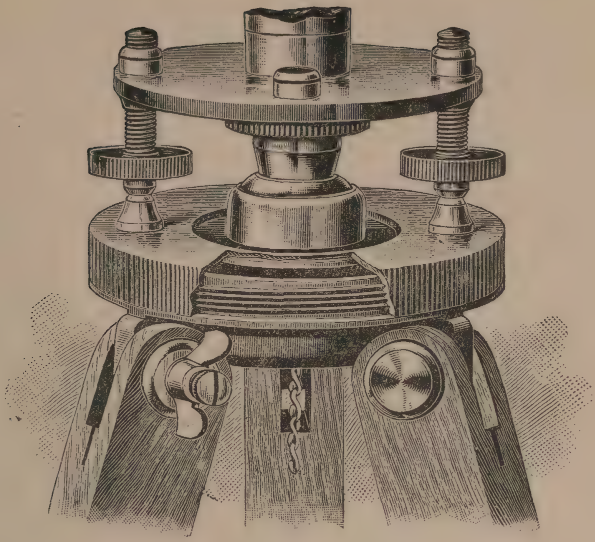
It forms a desirable method, whereby the wear of a screw is constantly taken up and dead motion prevented.

We have improved upon this by an addition, so covering the tangent as to prevent dust, dirt, &c., from reaching it.

There are other points of improvement in our tangent screw, such as length of attachment, by which the screw is kept acting more nearly at a tangent.



CLAMP AND TANGENT.



ATTACHMENT TO TRIPOD.

Patent Shifting Tripod.

(*Patented July 13, 1858.*)

By simply loosening the level screws, the instrument can be shifted a small distance in any direction, after the instrument has been set approximately.

The great convenience of this is evident to every Engineer. It is preferable to all imitations, inasmuch as it may be called self-acting, the wire levelling up screws to ordinary tension holds instrument firmly in its place.

Young's Improved Telescope.

(*Patented by John W. Nystrom and Alfred Young.*)

The several years of consideration of our Improved Telescope since date of our patent, has enabled us to so perfect it as with confidence to request attention of Civil Engineers to the valuable modification of Engineering Instruments.

This Telescope, the joint invention of Mr. John W. Nystrom, the well known scientist (the inventor of Nystrom's Calculator, and other improvements, and the author of standard mathematical and mechanical works),

and ourselves, combines the following advantages, when compared with ordinary constructed Telescopes:

UNIFORM LENGTH OF TELESCOPE, allowing the Telescope to be balanced in all positions, avoiding the constant annoyance in the Transit of the different lengths in reversal; and as constructed, allowing a longer telescope for ordinary distances for same height of standard, or lower standards for same length of telescope.

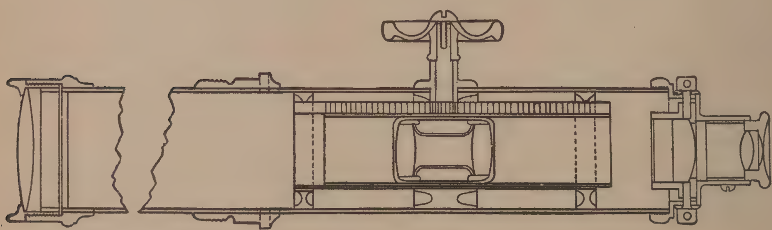
STATIONERY POSITION OF THE OBJECT GLASS, preventing the error arising from the change of position by the irregular motion or shake in the slide.

COMPLETE CLOSING OF THE TELESCOPE, so that no dust or other matter can get upon the slide or inside of the tube.

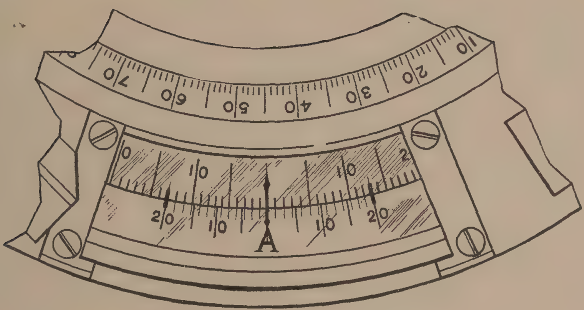
IN MINING INSTRUMENTS, this invention has proved itself exceedingly desirable and popular. Our light mountain and mining instruments, besides totally excluding dirt, and maintaining the higher power of telescope, give a clear reading to within four feet.

DISADVANTAGES.—Loss of light and impossibility to use Stadia Hairs, either fixed or adjustable.

To meet the increased cost, a charge of ten dollars additional will be made for each instrument on which the improved telescope is placed.



Non-Extension Telescope.



Improved Verniers.

(PATENTED.)

There has been granted us a Patent for Improvement in VERNIERS and GRADUATED PLATES, important, as producing

INCREASED ACCURACY IN READING GRADUATIONS,
A REDUCED SIZE OF INSTRUMENT, and
A REDUCTION IN WEIGHT.

The facility of vernier readings is determined by the closeness of vernier and plate. The weight of the Transit instrument is determined mainly by the size of graduated plate, and the necessary proportions of other parts thereto. The graduations of larger and smaller instruments, where difference in size is not too great, being generally performed on same Graduating Engine, there is no difference in the accuracy of the Graduations; but, as the larger the circle has the greater difference between the lines of gradu-

ation, it is the more easily read. This same difference can be produced on a smaller circle by a higher magnifying power of the reading glass, the use of which is, however, limited by two serious objections, evident from a consideration of the construction of the vernier and graduated plates as generally used. To read perfectly, two conditions have been heretofore necessary; first, that the vernier and plate should be in close contact, in order that the continuity of agreeing lines on the two should not be destroyed; second, that both plates and vernier should be on same plane, in order to avoid the error of parallax. Exactness in the first of these is impossible, as the surfaces moving upon each other, the edges on both would become rubbed, and the graduations destroyed. There must consequently be some space left, and this space is so enlarged by the magnifying power of reading glass, that the continuity of agreeing lines becomes destroyed, and the readings become uncertain. In addition to this, by the usual method of reading, this space is viewed at an inclination, and the line of sight passing so inclined from edge of vernier to plate, and striking *below* graduations and not against them, rendering accuracy yet more difficult, and produces error of parallax.

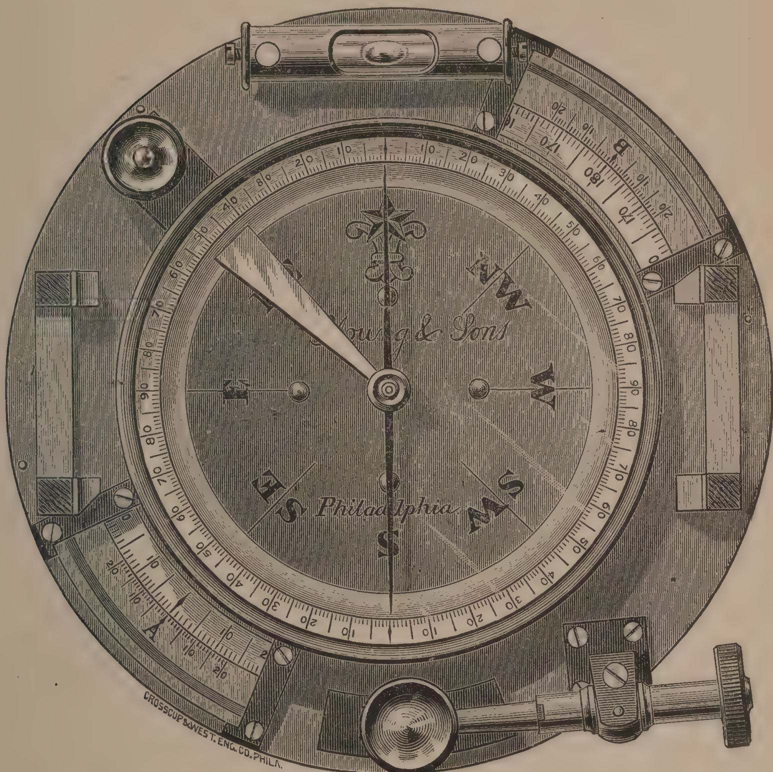
The remedy of this first evil is sometimes the adoption of the second, of placing the inside piece, vernier or plate, below the plane of other, so that the diagonal line of sight, when it reaches the inside piece, will strike beyond this space and give a continuity of lines. This construction is generally favored by Engineers; but as heretofore constructed, the accuracy is destroyed by the error of parallax, or by the difference of readings, as the eye is moved to one side or other.

There results from these considerations the indispensable condition, that in order to read verniers perfectly correct, *the eye must be situated in the vertical plane, passing through the agreeing divisions of vernier and plate, and the centre of the instrument.* To enable this to be done with certainty, and at same time to cause the lines on vernier and plate to *appear continuous and have no space between them*, is the object of our invention. We accomplish it, by placing above the first vernier, generally on the vernier glass, a similar vernier, graduated in whole or in part, so that by bringing the eye in range of corresponding graduations on the two, the eye must necessarily be in proper position, and parallax be completely destroyed.

So complete is this simple remedy, that while, without it, there is no certainty of the eye being in proper position by several inches, with it, the motion of the eye the tenth of an inch from its place becomes apparent. It also enables more rapid readings; and in positions where Engineer is cramped for room, as in mines or steep hill sides, the ability to place eye correctly is of exceeding convenience. Coincidence of readings by different persons is secured by this vernier, a result not hitherto attainable.

As an evidence of the importance of this improvement, we are enabled to make our Transit of 6¼ inch graduated plate read more closely than the larger instruments without it; and, while retaining the same telescope, leveling screws, &c., with same tripod, reduce the weight from 2 to 2½ lbs.;

and, by reducing tripod proportionally, save at least 4 to 5 lbs., retaining all the merits of the present larger instruments.



THE ABOVE ENGRAVING SHOWS MAIN PLATES OF OUR TRANSIT, AND THEIR RELATIVE WORKING PARTS, INCLUDING THE POSITION OF VERNIERS TO ONE SIDE OF STANDARDS, SO DECIDEDLY PREFERABLE WHERE THE ENGINEER IS WORKING IN CONFINED POSITIONS, AND SO MUCH MORE FAVORABLE FOR THROWING LIGHT UPON GRADUATIONS.

Tripods with Three Leveling Screws.

Applied to Transits Nos. 6, 7 and 13, and No. 1 Levels.

We are frequently consulted in regard to the relative merits of three and four leveling screws.

With the three screws, while not as convenient for transportation, the instrument is adapted to secure greater accuracy of results, by relieving centres from strain, and by securing more perfect horizontal adjustment, and is steadier when in use. In surveys, where accurate angles and long lines are called for, this construction is desirable. The objections are mainly the want of portability, the construction requiring larger base, consequently larger tripod head and legs in proportion, and an increase in the size of the box for the instrument. These disadvantages may at times prove to be so serious, we would advise the Engineer to give them careful consideration before ordering.

Leveling instruments not requiring a shifting plate, these objections are overcome, as but a slight difference in size of tripod head is required.

The Graduation and Numbering of Horizontal Circle of Engineer's Transits.

Transits of 6¼ in. graduations or larger, the horizontal circles are graduated to 20 minutes, and Verniers graduated to read single minutes, 30 or 20 seconds, as desired. **Unless otherwise ordered,** *the graduations will be numbered with one row of figures, from 0 to 180, in opposite directions, as shown on page 25.*

For the smaller size Transits, the circles will be graduated to half degrees, and numbered the same; Verniers will read to minutes.

For Mining Transits, and those to be used for triangulating, it is sometimes preferred to have an additional row of figures, from 0 to 360, or both rows, from 0 to 360, in opposite directions.

Aluminum.

The increased inquiries for instruments of Aluminum has induced us to make arrangements whereby we are enabled to obtain this metal in such quantities as to be prepared to fill orders. We do not, as yet, desire to endorse this metal as being suitable for the *whole* instrument, and we make wearing parts and screws of brass or hard metal, or bush the bearings. The additional cost of instrument generally ranges to twenty per cent. The saving of weight is about twenty-five per cent.

Engineers desirous of obtaining instruments of Aluminum, by addressing us will be more fully advised of cost, weights, etc.

GRADUATING ENGINES.

With this edition, we present to the Civil Engineers of this and foreign countries, a more complete view of our line of Circular Graduating Engines. From this they may be able to judge of our capacity, both positive and comparative, to insure accuracy in the most important part of their instruments; also to judge of the labor and expense we have incurred that the work may be faithfully performed, and be such as they can implicitly rely upon.

These Engines have all been made in our establishment. They represent a cost greater, we believe, than the combined cost of all the Graduating Engines in our country; and of themselves a cost greater than the combined cost of all the instrument establishments of this city.

They are:

A Foot Engine, of 22 inches diameter, used for Protractors, Needle Rings, and such work requiring heavy graduations, but not especial accuracy.

An Automaton Engine, of 24 inches diameter, upon which is placed finer work, and which is capable, by late test, of finer graduations than any similar engine of this country.

The large Automaton Engine, 48 inches diameter, which is intended for the finest astronomical and other work, and which is unequalled and unapproached by any such engine here. *Upon this engine we now graduate our Engineers' Transits, etc.*

The vital point of any instrument is the graduation. Defects in other parts may prove an annoyance or inconvenience, and yet instrument work correctly. With defects of graduation, accuracy, if not impossible, is a mere matter of accident. Defects in ordinary parts of instrument become evident to the Engineer. In the graduations they are unknown; and frequently the only evidence of their existence is the unsatisfactory condition of the finished work, leaving the Engineer in doubt whether the unsatisfactory results, condemning his work, arises from his own carelessness or the imperfections of his instrument. It is not necessary errors should be found in all parts; the mere fact that an error may exist anywhere is sufficient to throw doubt upon the work. In fact, the want of *positive knowledge* that *no error* CAN *exist*, is sufficient to make every conscientious Engineer hesitate in the choice of an angular instrument.

While imperfect graduations most frequently arise from imperfect engines, a common cause of error is carelessness, or inexperience in manipulation. The delicacy required in graduations of Transits, &c., is such that reliance cannot be placed upon personal operation. The heat of the body in contact with the engine, the uneven strain placed upon the parts by the hand, the uneven velocity, and especially the many evils resulting

from the long continued strain upon the attention of the individual, make the AUTOMATON movement necessary for any approach to perfection.

Errors of graduation frequently run in periods, so that one or two repetitions, should they fall within these periods, give the same, though false results.

It sometimes happens that the regular errors of engine are partially balanced by accidental errors in process of graduation, which is one cause of different amounts of error to be found in the different instruments of some makers; and which, perhaps, partly accounts for certificates of performances of some instruments, ascribing to them a certain maximum error, when it is well known the error of engine upon which they were graduated is four or five times that amount. But as these accidental errors the next time may increase instead of diminishing the regular errors, it is manifestly unsafe to rely upon such certificates for what the next instrument may be.

In surveys requiring large triangulations, the accuracy of results being in proportion to the accuracy of graduations, we feel justified in considering it a matter of prudence on part of Engineers in charge, to avail themselves of the facilities which our labor and investments afford them.

With our perfect provisions for securing accuracy in graduations, there remains but one obstacle, the error of Parallax,—completely removed by our Patent Vernier,—so that the Engineer using one of our late instruments, can congratulate himself upon having one, for working purposes,

SUPERIOR TO ANY NOW MADE.

Engineers are reminded of the great superiority given our TRANSITS, in addition to the merits of their graduation, by our

PATENT VERNIERS,
PATENT TRIPOD,
IMPROVED EYE PIECE,
IMPROVED SLIDE PROTECTOR,
IMPROVED TANGENT,
IMPROVED TELESCOPE,
GRADIENTER,
OPPOSING PIECE.

No Transit now made approaches these instruments in perfection, accuracy or convenience. They are the ONLY instruments to which any bona fide improvements have been added.

TELESCOPES.

Telescopes placed upon our instruments within the past few years have, as we remarked, a higher power than was formerly placed upon the generality of these instruments.

The general demand is for a high power; and those unacquainted with subject consider the higher power the better telescope. The *power* of a telescope depends upon proportion of focal lengths of object glass and eye piece, and while in theory *any* power may be given to any telescope, in practice the extent is limited by other *points*, such as effects of abberation, loss of light, and size of field of view. With the same object glass *every* increase of power is followed by a decreased illumination, or a decrease of light and a smaller field. These results follow in obedience to mathematical laws, and cannot be obviated. Science has given certain proportions between power and length of telescopes, and the best opticians of Europe, with their extended experience, invariably follow these proportions.

The practice in this country of late has been to force the power beyond these bounds; the result is, that while under very favorable circumstances the centre of field of view will give a somewhat better definition, it will only do so under favorable circumstances, such as clear atmosphere and strong illumination of the object, and that either the field must be much reduced or objects out of immediate centre will not be in focus. In cloudy weather, in lesser light of morning and evening, in the tremulous condition of atmosphere, arising from evaporation from surface of ground, especially cultivated, these high powers all suffer.

There are purposes, where great definition is so much an object as to supersede all other telescopic requirements, in which these high powers are advisable; but the Engineer should understand that in using them what he loses on the other points, and especially remember the exact focusing required of them, otherwise parallax produces a sensible error. For rapid working the exact focusing of high powers is a drawback,—a change in telescope being required for almost every small change of distance. Comparison of two telescopes differing widely in power will illustrate this. In the lower powers, in ranging a line, distances between 300 and 400 require little if any change, and same of say 500 and 700, or 800 and 1200; but in higher powers every change of a few feet, until practically parallel rays are reached, requires separate focusing, and if not properly focused are liable to be less distinct than the lower powers.

The loss of light, even in the best high powers, is what gives an impression of glass being "less distinct" on its first use, for though smaller objects are better defined by it, the impression on its first use is one of cloudiness.

Fortunately the particular use of engineering instruments requiring definition on but one point at a time, allow us to make other conditions of optically good glass subordinate to this one of power to a great extent.

INVERTING glasses are not more powerful, except that from small space occupied by the eye piece, they allow for same length of telescope a greater focal length of object glass and thus increase the power.

They however have a much greater amount of light, or greater illumination and a much larger field. The prejudices of American Engineers are against them, but in Europe, &c., their merits are almost universally acknowledged, and they are almost the only ones used.

We have remarked on this subject because of the gradually increasing interest of Engineers, and that they may form an idea of the principles governing instrument makers, desirous of giving the best general, but not sensational, properties to the telescope.

As a rule we give such power as possible without positive injury. Our Transit telescopes of 10 inches in length have power of 20 to 22; of 11½ inches in length a power of 23 to 25. The Levels a power ranging from 22 in our 17 inch to 50 in our 22 inch.

Changes in these powers can be made; but we advise Engineers not to make them without consideration.

STADIA

With the higher powers given our telescope of late years, the introduction of Stadia wires has been more frequent and accuracy of measurements made by them proportionally increased.

Within certain bounds, and with use of self-reading rod, they can be made fully as accurate as the ordinary rough chaining with the old heavy chain. When great distances are used, when distance is beyond perfectly distinct vision of telescope, the advantage is on side of chaining; for while, other circumstances being the same, the percentage of error in chaining, which is analagous to determination of angle in stadia, remains constant, the distinctness, or the facility of sighting to any determined limit, say the hundredth of a foot, decreases rapidly with increase of distance. Experiments and actual work confirm these conclusions.

Over rough ground the advantage is in favor of stadia, while over smooth ground, especially with the lighter chains and the chain tapes used, it must be careless chaining that does not give better results.

The angle of inclination forms a difficulty in using stadia wires, requiring a measurement of this angle and calculation for purpose of reduction, or some means such as our right angled sight to bring the rod perpendicular to line of sight. The right angled sight is carried by the rodman; one

arm is held firmly against the rod while the eye ranges the other arm to the instrument; so the measurements are made on the rod as on a right angled base.

Exact measurements of base being required, at great distances the two targets must be used and set, causing the work to be comparatively slower.

Want of flatness in field of view is a great disadvantage in the stadia, but one that cannot be avoided, except in perfection of telescope. The observer should be careful to obtain exact focus, as out of focus the image of rod occupies a larger space, while stadia wires cover always the same.

Measurements by stadia do not start from centre of instrument, but from a distance beyond object glass equal to the focus of object glass. This distance may be found by measuring from face of object glass to the cross-web, which is generally one-quarter of an inch nearer the eye than middle of cross-web screws. The correction thus found is a constant, to be always added to distance of observation.

There are two methods of attaching the stadia wires—the fixed and adjustable.

The fixed are fastened on web piece along with the regular wires; they are upon same plane, and in adjustment of wires there is no motion of one upon other to drag either out of place. By an improved arrangement in connection with our straight line engine we are enabled to place the cross-webs in proper position, with as much, if not greater, exactness than they can be adjusted, and the distance between middle wire and the two outside wires always remains constant, no matter how much the middle one may be changed by losing its adjustment or by process of adjusting.

In the adjustable attachment the distances between webs are much more liable to change, and even in constructions, intended to avoid the difficulty, are necessarily affected, not only by their own adjustment, but as well by that of regular wires, and this not only in width of outside webs, but especially in the distances of these from middle ones.

There are few occasions in which use of stadia can supersede the use of the chain; but there are many in which they become extremely useful, and considering the accuracy of which they are capable, and that they in no wise interfere with other uses of instrument, they form a desirable addition. For moderate distances, across ravines, streams, swamps, for measurements in topographical surveys, and for checks on the chain, they are of great value. For topography, especially, they are excelled by no arrangement but our Gradienter.

LEVELS.

Our Levels are divided into two classes. In No. 1 and 3 the levelling screws are attached permanently to the centre, and the instrument detaches only from tripod; the object is to afford a somewhat better protection to the centres, which pass down through the plate carrying the screws.

In No. 2 and 4 the telescope and bar detaches from levelling screws, which likewise detach from tripod. The object is to allow the most important parts, telescope and level, to be speedily detached and carried separate.

The telescopes, level, bar, screws, &c., are the same in both instruments.

The LEVEL TUBES used are ground uniformly the whole extent of the circumference, as giving a more perfect form and more regular motion than where ground merely upon the upper surface. This form, though more expensive, we have found the only one to be relied upon.

The curve of surface is such as to give an angle two minutes for each inch of motion of bubble, or for each division on scale an angle of twelve seconds; and as difference in reading of two ends of bubble indicate double actual motion of bubble, it follows that each difference of one division between two ends of bubble indicates an angle of six seconds.

This is the usual rate. For lighter levels it is made less, and for special circumstances increased, frequently doubled.

As a general rule, the more sensitive the bubble the more perfect the work, but in an exceedingly sensitive level will not remain stationary and is difficult and annoying to work. On the other hand a dull level, while it gives the appearance of steadiness to instrument, and an impression that it "keeps" its adjustment, is incapable of accurate results. The instrument which retains adjustment of level should be examined by testing the value of motion of bubble, to ascertain if it is in consequence of a good or a bad quality.

The 22 inch Telescope Level is intended to meet the wants for an extra instrument, as for city and hydraulic work. The telescope is larger, the centres are longer, the tripod wider, and the levelling screws are passed through nuts that can be tightened, so as to insure perfect steadiness on this part. The level is extremely sensitive, and the whole instrument arranged as to give the most accurate results possible.

IMPROVED LEVEL.

Patented by L. B. DENISON, Feb'y 3, 1880.

The aim of this Level is to furnish an instrument which is capable of

INCREASED STEADINESS,

USE OF MORE SENSITIVE SPIRIT LEVEL,

SMOOTHER MOVEMENT OF LEVELLING APPARATUS.

The object is accomplished :

1st. By use of longer radius upon which the levelling motion is made.

2d. By use of independent centres for the motions, at right angles to each other.

3d. By having these centres unconnected with the attachment of the levelling screws, so that the action of the screws neither tightens nor loosens the centres upon which the levelling takes place.

This action of the screws in one direction being effected upon their own centre, without any movement or direct action upon the centre on which other screws move, leave the whole instrument free from strain.

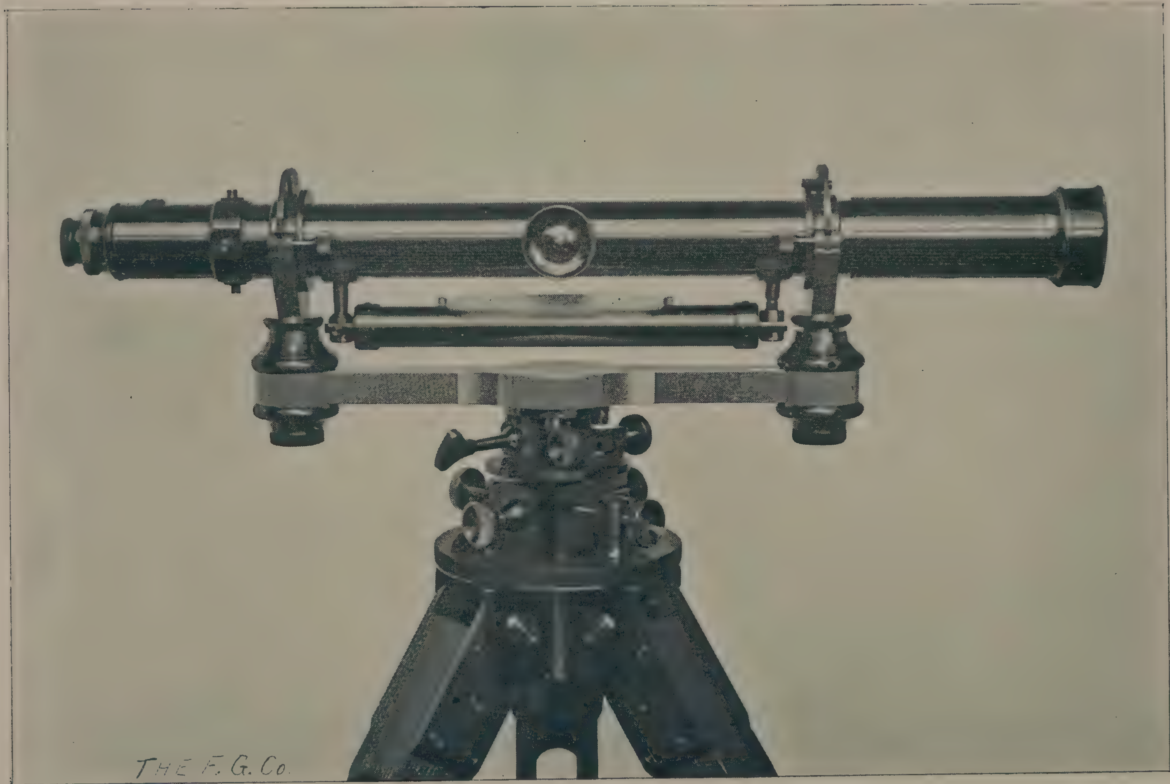
By the construction, the centre upon which the instrument revolves can be made longer, while the whole instrument is kept lower in the tripod. This length of centres is another cause for increased steadiness, to which the low position on tripod contributes, and is an end sought in all instruments.

For City and Hydraulic Engineering, for the finer kinds of Railway work, such as depots, buildings and track levels, this instrument will be found more satisfactory in its workings and results.

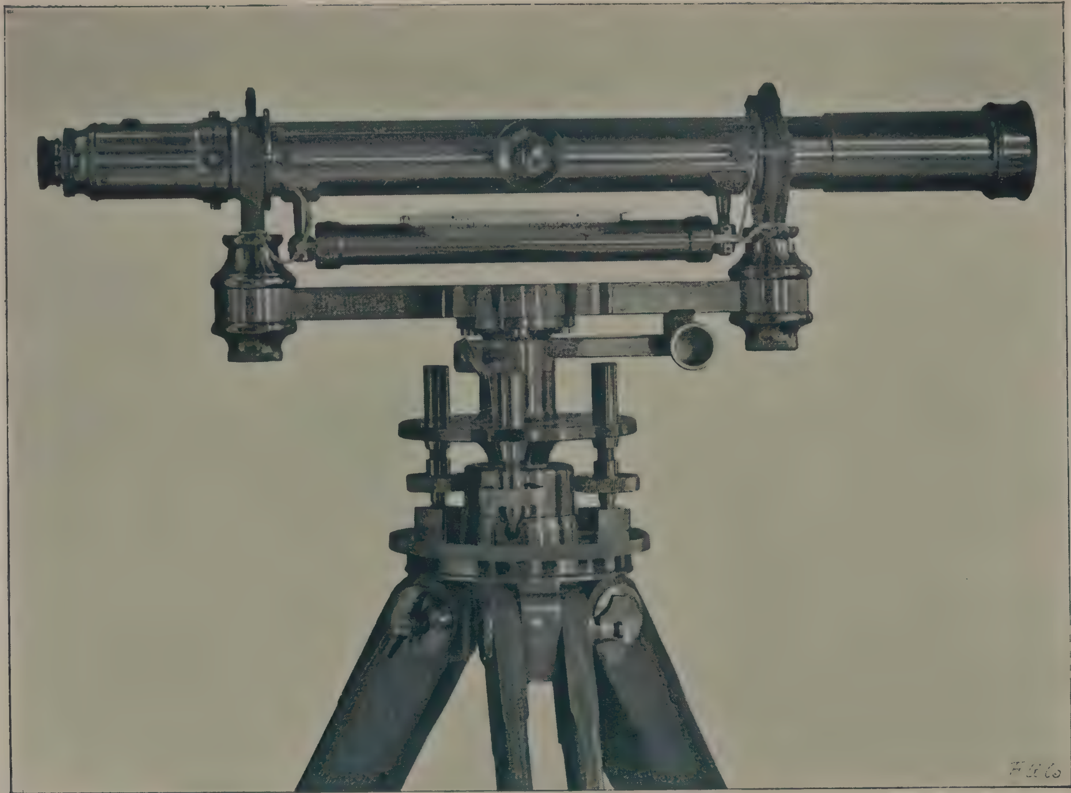
PRICES:

All our improvements on telescopes, etc.

For in. telescope, power	. . . .	
" 18 " " " 40,	. . . .	175 00
" 20 " " " 45,	. . . .	185 00
" 22 " " " 50,	. . . .	200 00
With plain Telescope. including Improved Web Fastener,	18 in. Telescope, .	135 00



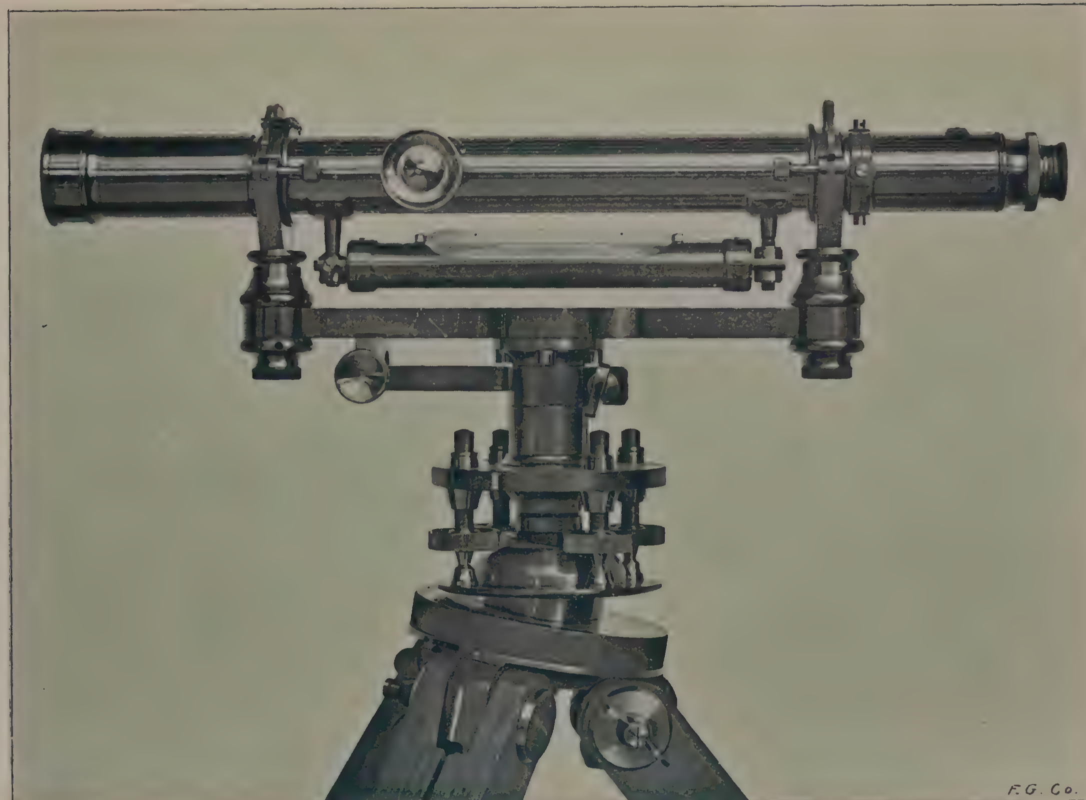
DENISON IMPROVED LEVEL.



NO. 1—LEVEL, WITH 3 LEVELING SCREWS

Price, with Telescope, 18 in. long,	$160 00
" " " 20 " "	170 00
" " " 22 " "	195 00

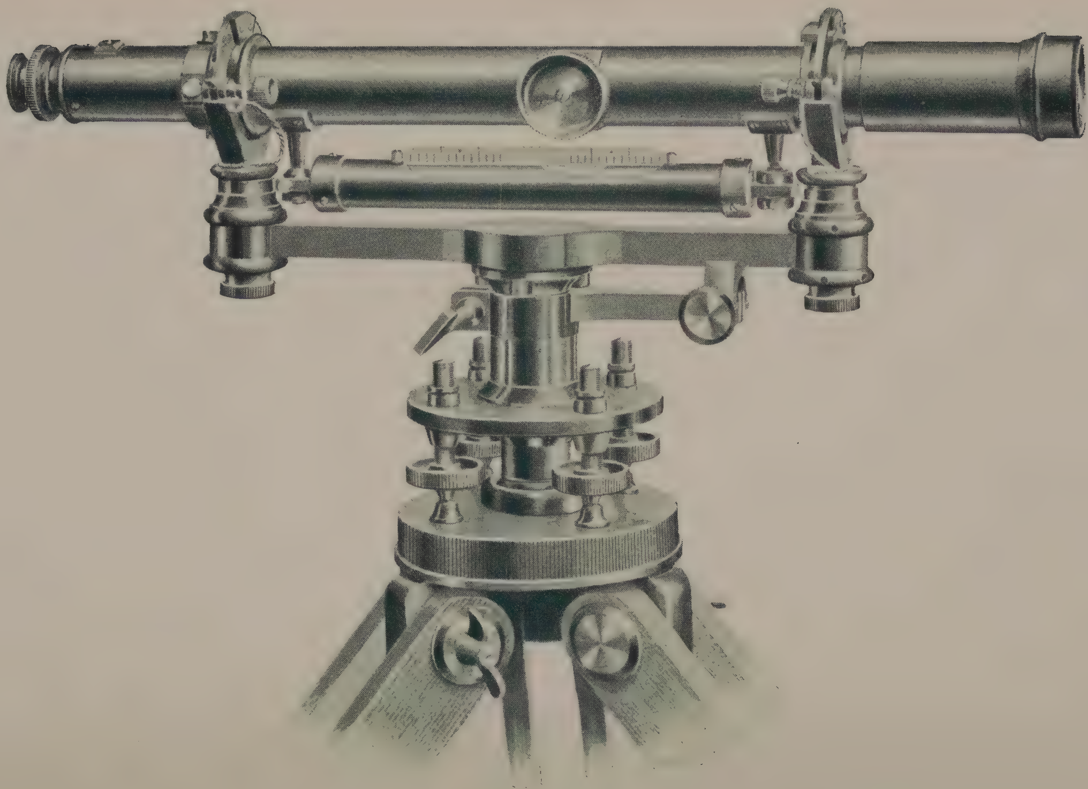
For Description, see page 35.
See also Page 26.



NO. 1.—LEVEL WITH QUICK LEVELING ATTACHMENT

Price, with Telescope, 18 in. long,	. . . .	$160 00
" " " 20 " "	. . . .	170 00
" " " 22 " "	. . . .	195 00

For Description see page 35.



NO. 1—LEVEL

Level No. 1.

No. 1.—*The centres are connected permanently with the level screws, and instrument detaches only from tripod.*

Telescope,	inch, power		weight	. . . .	
"	18 "	" 40,	" 17¾ lbs.,	. . .	150 00
"	20 "	" 45,	" 18½ lbs.,	. . . .	160 00
"	22 "	" 50,	" 22 lbs.,	. . . .	185 00
Stadia Hairs fixed, extra,				. . . .	3 00
" " adjustable, extra,				. . . .	8 00

The screws pack in box with instruments.

The instruments are furnished with

Young's Improved Eye Piece,
" " Slide Protector,
" " Fastener, to keep vertical and horizontal cross-webs in position.

The instruments are furnished with shade, cap, screw-driver and levers.

No. 2½, Light Level.

Telescope, 15 inch, power 31, weight 11 lbs., ... $90 00

This level is capable of all adjustments of larger instruments.

Tripod, with Three Leveling Screws, for No. 1 Levels, $10.00 additional.

See pages 26 and 47.

Level No. 3.

In the No. 3 *Levels, the centres are connected permanently with the level screws, and instrument detaches only from the tripod.*

PRICES: Telescope	18 inches long,	. .	$110 00

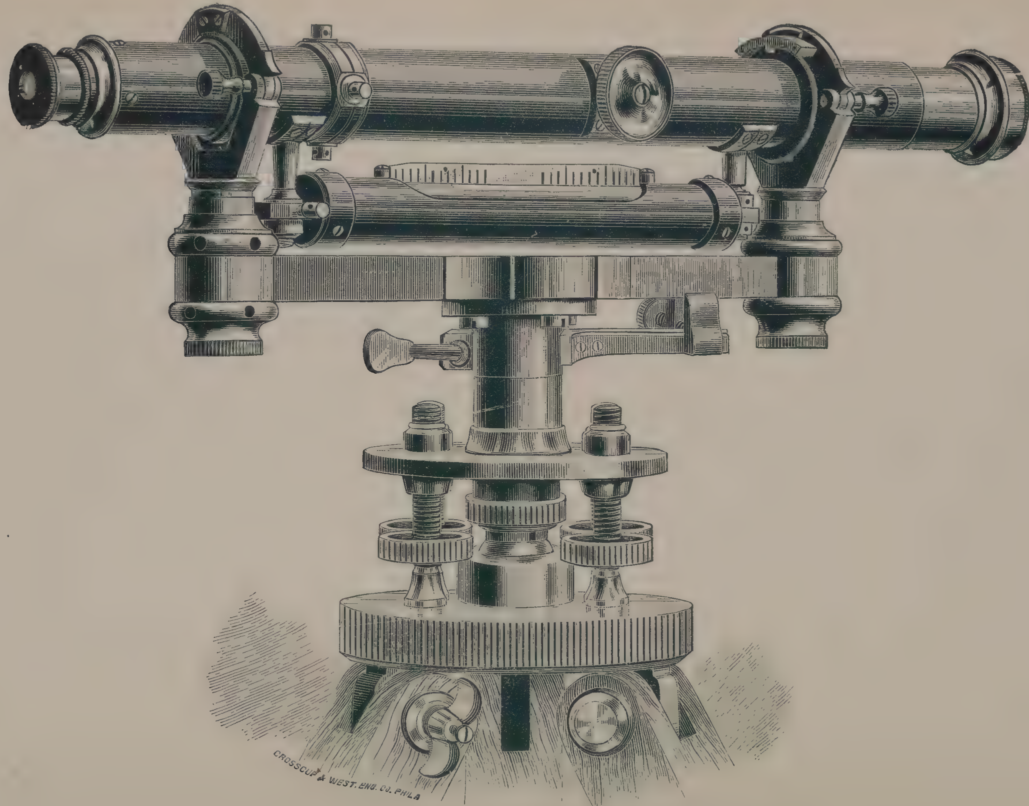
The difference between our No. 1 Level and our No. 3 is in the telescope.

In Level No. 1 the glasses are of the best American make, and the telescope contains all our improvements, namely,—Improved Slide Protector, Eye Piece, and Web Fastener.

In Levels No. 3 the glasses are of first-class London make, and telescope has our improvement of Web Fastener only.

EXTRAS FOR NO. 3 LEVELS:

Improved Eye Piece (see page 18), ...	$10 00
" Slide Protector (see page 20), ...	5 00
Stadia Hairs, Fixed, ...	3 00
" " Adjustable, ...	8 00



NO. 3–18 INCH LEVEL

TRANSITS.

From the various instruments made in ordinary course of our business, we have selected the following list as being the most usual, and one that will meet the wants of almost the entire range of instrumental work.

Larger instruments, and of many different patterns to suit especial work, have been sent from our establishment, but their enumeration would be too long for our purposes.

While, for railway work, our No. 6, smaller size, and for town work, &c., No. 6, larger size, will meet general requirements, we are frequently called for instruments in which accuracy is not so much desired as ability to stand rough usage, and yet more frequently for instruments capable of greatest exactness.

In construction, the principal division of Transits is into long and flat centres. The flat centre is best adapted to withstand rough work, and is in many respects the most portable. The greater friction of plates upon each other, and the consequent wear upon centres, makes it less reliable for angular measurements, and where level is attached to transit telescope, the instrument is not so steady. The peculiar construction of centre, being a flat cone, prevents this part from injury by a fall, and makes the correction of shake in centre a comparatively easy matter to the Engineer himself.

In the long centre instrument there are two cones, one inside the other. The weight of instrument is received on a shoulder of these centres, while the long conical fittings relieve this weight to a slight degree, and when properly fitted prevent all shaking. Any injury to the centre, however slight, though is exceedingly serious in its results, generally renders instrument useless at once and cannot be remedied outside of instrument makers. Nevertheless, the superiority of this form for angular measurements causes its almost universal adoption.

TELESCOPES.—The telescopes on our Transits are made to reverse either end, except on special occasions. The power is graduated to the work to be performed, ranging from 14 on our smaller ones to 30 on the larger.

The main principles governing application of telescopes will be found under head "Telescopes."

The *Eye Piece*, upon which much of the perfection of telescope depends, receives especial attention. Generally, and unless otherwise ordered, the erect eye piece is used. For Mining purposes, Tunnel instrument, and for highest class of instruments the inverting is substituted.

Diagonal Eye Pieces for observations of stars for meridian, as well as for observations at larger vertical angle than with ordinary eye piece, are generally made by us with a simple prism attachment, as being the most convenient and expeditious.

Reflector Plates for illumination of cross-webs, for observation on stars, for work in mines, where light received is not sufficient of itself, are attached by us to the object glass, by means of a frame work holding a reflector plate faced with solid silver, and placed at an angle with axis of instrument. This plate is perforated at centre to allow observation of object, while the light of a lamp held backward and sideways is reflected upon cross-web.

The *Compass Needle* is made of careful forgings, greatest measure vertical, to insure steadiness and avoid that unsteady motion mistaken sometimes for sensitiveness, which is of no service to needle, but an annoyance to the surveyor. It has also a large cross section to secure magnetic power, a matter we regard of consequence, the flat, thin or square needle used on second class instrument being merely a device to save cost of construction.

Compass Face in all but smaller instruments are bronzed, to prevent reflection of sun into the eyes. A small silvered ring, immediately under end of needle, secures all the advantage of the full silvered face.

Verniers of our instruments are so placed that they may be easily read while in position to observe through telescope. The advantage of being able to read, or set off an angle, when in confined positions, or upon ground where any motion of Engineer would disturb the instrument, is so great that, once accustomed to them, Engineers always give them the decided preference. The light upon the verniers is more in this position, not being so much interfered with by the standards. Verniers are in all cases double, reading right and left.

Decimal Verniers.—Graduations into decimal parts of a degree has been placed upon our instruments for many years, before being adopted on any others. Its adoption is due to Samuel W. Mifflin, C. E., and its use is almost universal amongst the Pennsylvania Rail Road Engineers, and those who have graduated under their instruction. The great advantage is convenience in deflecting for curves, the targential deflection for a 2° curve being the hundredth of a degree for each foot of distance, and in proportion curves of other radii.

The general way of placing on our Transits is to make one vernier decimal and one into minutes.

The level to telescope, with tangent or opposing screws, the vertical arc, and the gradienter, are considered as attachments to the plain Transit. They can be placed upon any of the instruments, and do not in any manner modify the main parts.

The Level, as placed upon telescopes of our Transits, is as sensitive as those usually placed upon the level instruments of other makers. The divisions are generally placed upon the glass itself in preference to the brass scale.

The opposing screws for holding this level hold it firmest in windy weather, the tangent screw or spring gives the smoothest most regular motion.

The Vertical Arc with Loose Vernier, as introduced by us 24 years ago, is almost entirely used by us. The full vertical circle is, from its

peculiarly exposed position, constantly liable to injury, and when but even slightly injured, is not only useless itself but interferes with other use of instrument, by throwing line of collimation out on reversals. The loose vertical arc measures 60° either way, and by repeating may be made to measure 180°. No injury to it affects the other part of instrument. Its introduction was a decided improvement on Transit.

Tangents are generally made with a double spring, to prevent lost motion in screw. As a decided improvement we cover them to keep away dirt, reducing the wear and giving a much smoother motion, without necessity of so tightly clamping or springing nuts to force dirt out as it enters these nuts.

They are placed over the instrument to protect them from injury, while the point of attachment is so far from the clamp where it touches plate, that the smallest motion does not deprive it of all resemblance to a tangent.

The DUST COVER is broad, running a long distance under plate, so as to effectually exclude dust from between the edges of graduated plate and vernier.

TRIPODS.—The legs are made of best seasoned, straight grained wood. The shoes are of cast steel; points of sufficient thickness to allow sharpening often,—a matter of consequence, as dull shoes are a great drawback to steadiness of instrument.

The *weight* of an instrument is frequently reduced by reducing the weight of tripod at a sacrifice of steadiness. A tripod too light destroys all the merits of an instrument.

All Transits are furnished with plummets, reading glasses, adjusting pins, screw-drivers and shades, and levelling screws in all cases pack in box.

All telescopes balanced generally made to revolve at both ends.

Improved Engineer's and Surveyor's Transit.

No. 3.

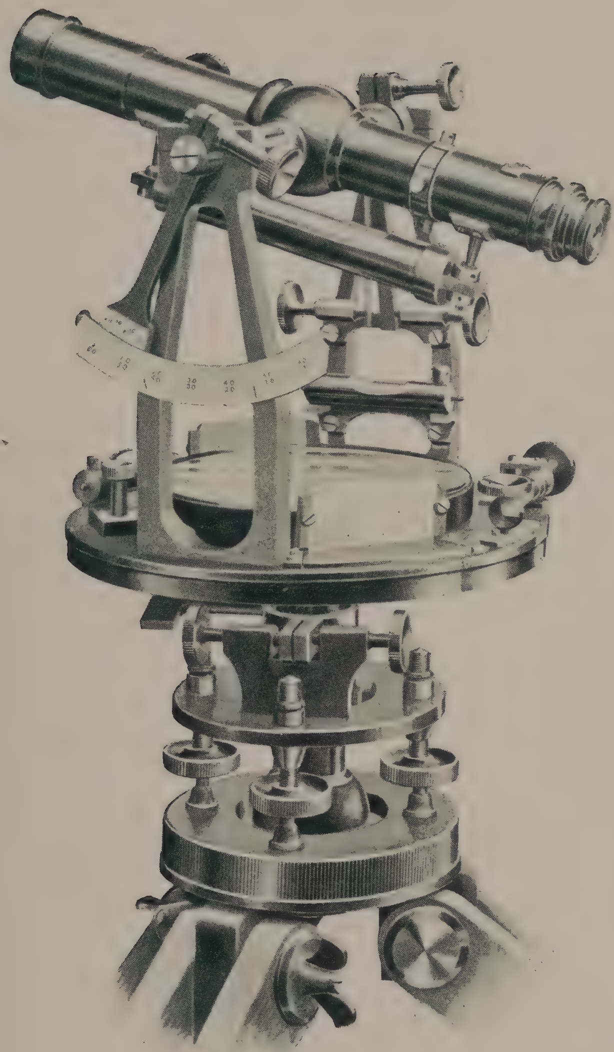
A portable and convenient Transit for general work. Suitable for preliminary surveys and work of ordinary accuracy.

Power of Telescope, 20; long centre; outside Vernier to Plates: Verniers reading to minutes; vertical adjustment to Telescope; Needle, 4½ inches; Graduations, 6¼ inches; Improved Eye Piece; Tangent to Plates; Improved attachment to Tripod; Screws pack in box $160.00

These instruments are furnished with

YOUNG'S SLIDE PROTECTOR,
" TANGENT,
" OPPOSING PIECE,
" PATENT SHIFTING TRIPOD.

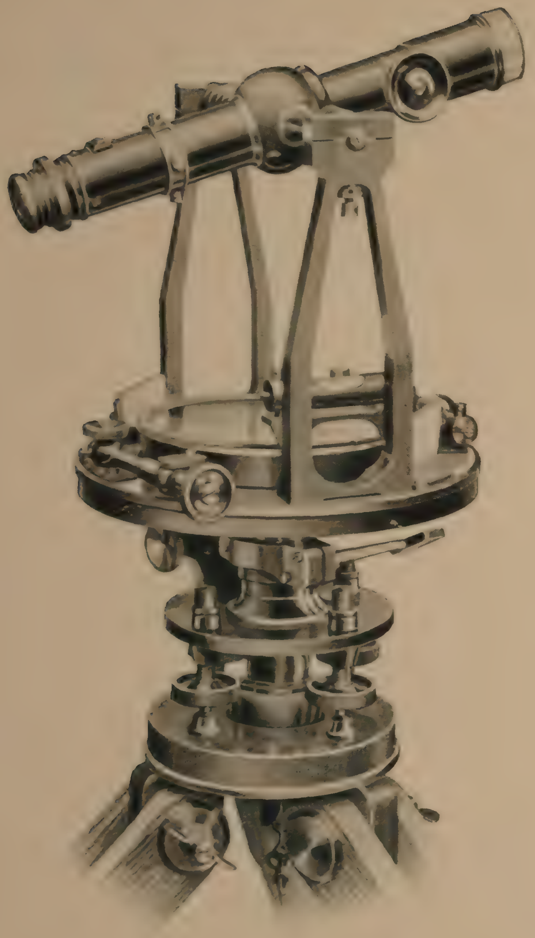
With the addition of a plate and vernier for setting off the local variation of needle, this instrument is the one we recommend to surveyors. Price of Variation Plate and Vernier, $10.00 additional. See also Solar Attachment, page 60.



NO. 3—COMPLETE TRANSIT

PRICE, AS SHOWN ABOVE $190 00

For Description, see page 40.
For Extra Attachments, see page 56-A.

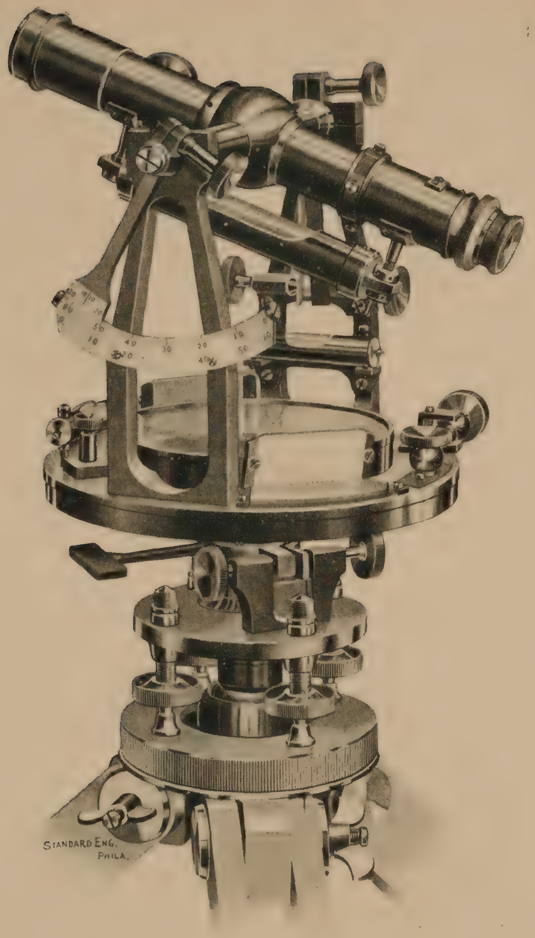


NO. 6.—PLAIN TRANSIT.

PRICE, AS SHOWN ABOVE

With 4½ in. Needle, 6¼ in. Graduations	. . . .	$200 00
" 5 " " 6¾ " "	. . . .	210 00

For Description, see page 41.
For Extra Attachments, see page 56-A.

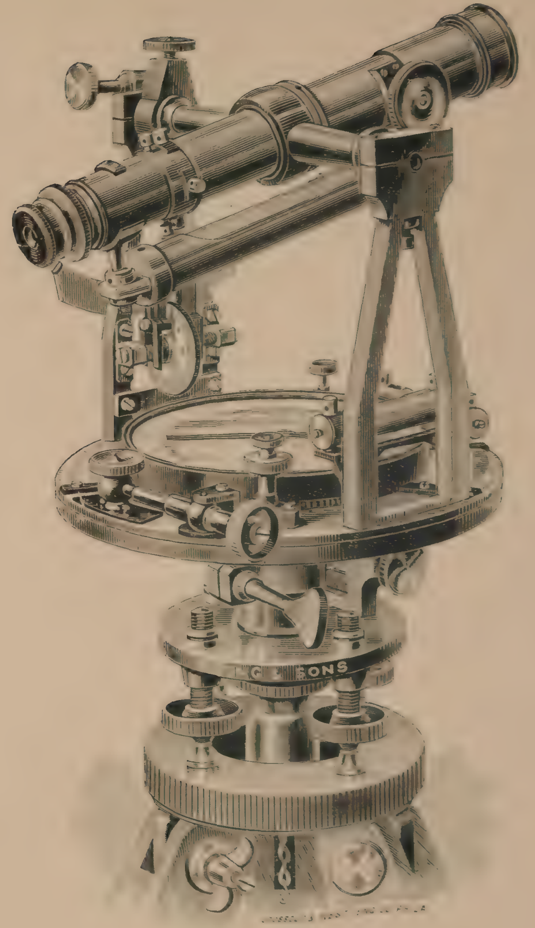


NO. 6.—WITH LEVEL TO TELESCOPE, CLAMP AND OPPOSING SCREWS, AND VERTICAL ARC.

PRICE, AS SHOWN ABOVE

Needle 4½ in. long, Graduation 6¼ in.	. . . .	$240 00
" 5 " " " 6¾ "	. . . .	250 00

For Description see page 41.
For Extra Attachments, see page 56-A.



NO. 6.— WITH GRADIENTER LEVEL TO TELESCOPE, AND VERTICAL ARC.

PRICE, AS SHOWN ABOVE

With Needle 4½ in. long, Graduations 6¼ in.	. . .	$255 00
" " 5 " " " 6¾ "	. . .	265 00

For Description see page 41.
For Extra Attachments see page 56-A.

No. 6.

This we consider the Transit best adapted for general purposes and for Railway work. The 4½ inches Needle and 6¼ inches Graduation is our standard for Railway work, and the instrument we send when one is ordered without limitation as to size or quality.

Power of telescope, 20 to 24.
Long centre.
Two outside verniers, reading minutes, or one minutes and one decimals.
Needle, 4½ inches.
Graduations, 6¼ inches.
Tangent to plates.
Vertical adjustment to telescope.
Improved attachment to tripod.
Screws pack in boxes, ... $200 00

With needle 5 inches.
With graduations 6¾ inches, ... $210 00

These instruments are furnished with

Young's Improved Eye Piece,
" " Slide Protector,
" " Tangent,
" " Opposing Piece,
" Patent Shifting Tripod.

For Tripods, with Three Leveling Screws, see pages 26 and 47.

No. 7.

For City and Bridge Engineering.

The improvements on these instruments are well adopted to use of Railway and other Engineers.

A large proportion of our business, within late years, having been in the construction of City Instruments, we have placed upon them several improvements, bringing them so near perfection, both in steadiness and delicacy, as to merit the attention of City Engineers.

In the important point of GRADUATION, all work is done under personal superintendence, upon Automatic Engines, the equal of which is not to be found, at least in this country. Our large Engine is capable of graduating circles of 54 inches diameter, reading readily with microscopes to tenths of a second. *The City Transit made by us is graduated upon this Engine.*

While making the smaller size, we recommend the larger, graduated to 20 seconds.

Power of telescope, 22 to 26.
Long centre.
Two outside verniers, reading minutes or decimals, or one minutes and one decimals; or both verniers reading 30 or 20 seconds.
Graduations on solid silver,

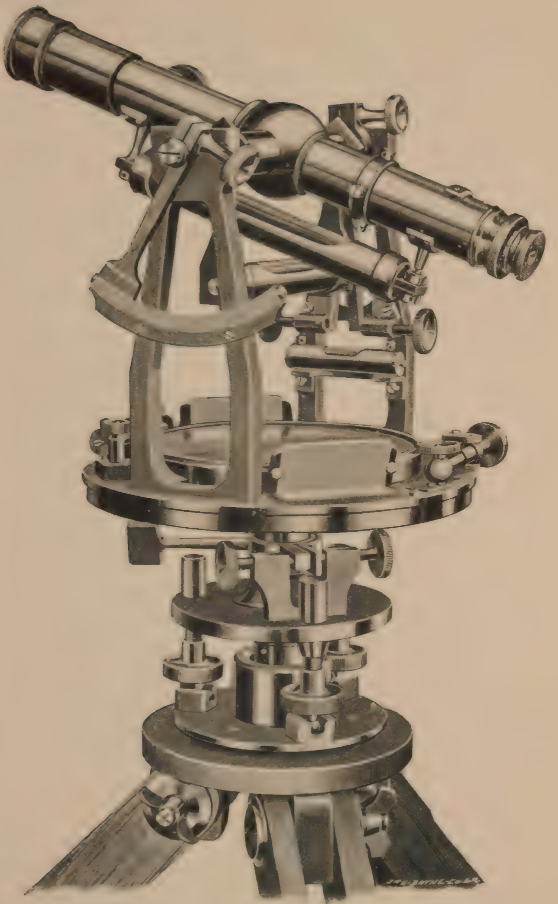
Tangent to plates.
Striding level suspended from vertical axis.
Vertical adjustment to telescope.
Telescope, large, either inverting or erect.
Improved attachment to tripod.
Screws pack in box,

With graduations 6¾ inches.
With needle 5 inches, ... $235 00

These instruments are furnished with

YOUNG'S IMPROVED EYE PIECE,
" " SLIDE PROTECTOR,
" " TANGENT,
" " OPPOSING PIECE,
" PATENT SHIFTING TRIPOD.

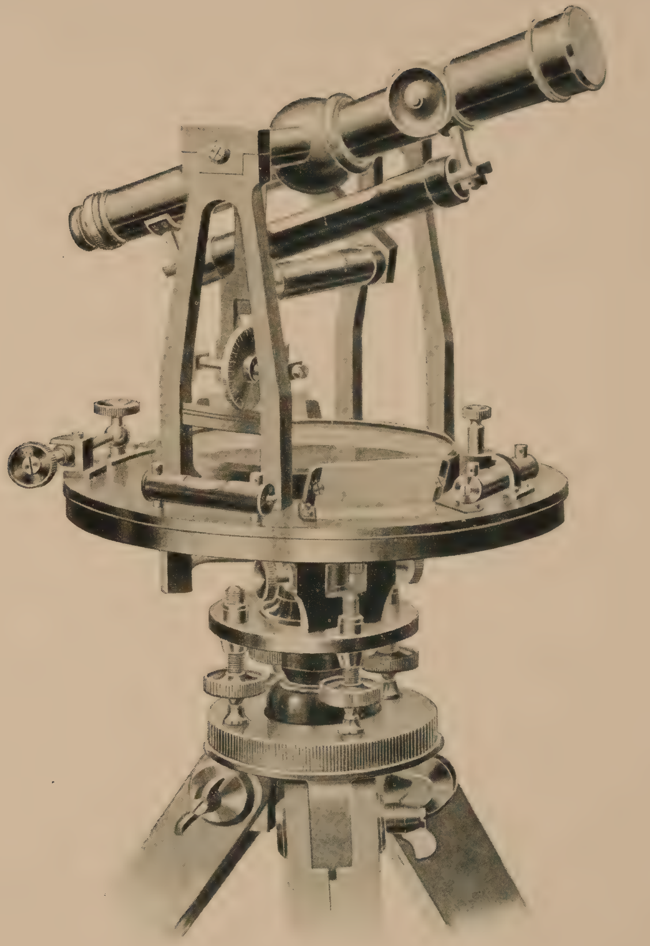
Striding level suspended from cross-axis of telescope.



NO. 7.–CITY AND BRIDGE TRANSIT.

Needle 5 inches long, Graduations 6¾ inches, reading 20 or 30 seconds, level to telescope, clamp and opposing screws and Vertical Arc. (Silver.) Three leveling screws, Price, . $300 00

For Description, see page 42.
For Extra Attachments, see page 56-A.
See also page 26.



NO. 7.–CITY AND BRIDGE TRANSIT.

Needle 5 inches long, Graduations 8½ inches, reading to 10 seconds, Gradienter, including Level to Telescope, Price, . $310 00

For Description, see page 42.
For Extra Attachments, see page 56-A.

NO. 7.–CITY TRANSIT.

Needle 5 inches long, Graduations 6¾ inches, reading 20 or 30 seconds, complete, as shown above, (90° Swinging Arc), $285 00

With 5 in. Needle, 6¾ Graduations, 60° Arc, Swinging Vernier, 275 00

For Description, see page 42.
For Extra Attachments, see page 56-A.

NO. 10.—MOUNTAIN OR MINING TRANSIT

Needle 3½ inches long, Graduations 4¾ inches, reading to minutes.

Level to Telescope, clamp and opposing screws, and Vertical Arc, Price, $225 00

Extension Tripod $10 00 extra.

For Description, see page 43.

For Extra Attachments, see page 56-A.

No. 10.

Mountain or Mining Transit.

This instrument is designed for Engineering as needs a light, portable instrument. In workmanship, graduations and proportionate strength, it is as reliable as larger instruments, principal difference being in weight. It has simply, in construction, the disadvantage of smaller circle and smaller needle.

It is equal to performance of all the ordinary duties of Railway work.

The centres are longer than the centres of the usual larger instruments of the country, being over three inches. The telescope has object glass of one and one-tenth inches diameter and a power of seventeen diameters.

The verniers are wide, extending to edge of plate, to allow extra amount of light. They have advantage of being so placed that the Engineer can read the plate without changing his position, risking the disturbance of instrument.

Long centre.
Two outside verniers, reading minutes or decimals.
Needle, 3½ inches.
Graduations, 4¾ inches.
Tangent to plates.
Vertical adjustment to telescope.
Eye piece, either inverting or erect.
Shifting tripod.
Screws pack in box, ... $170 00

These instruments are furnished with

YOUNG'S IMPROVED EYE PIECE,
" " SLIDE PROTECTOR,
" " TANGENT,
" " OPPOSING PIECE,
" PATENT SHIFTING TRIPOD.

No. 13.

City and Tunnel Transit.

Adapted especially for Straight Lines.

The axis of telescope is set upon Y bearings, and the telescope accurately balanced that it may move easily and not risk disturbance in revolving it. The axis bearings are cylindrical, that the telescope may be reversed on these bearings as well as revolved on them. This affords opportunity for testing adjustment of collimation speedily without change of instrument, or if not in adjustment, of marking two points the mean of which is correct.

A striding level suspended upon the axis tests motion of telescope in a vertical plane. For tunnel work, the eye piece is made inverting to obtain light when desired.

The instrument is frequently made with standards low, to secure greater steadiness. It then loses its character of transit, and the telescope cannot be revolved, but the reversal on axis bearings allows adjustments to be readily made and back sights taken.

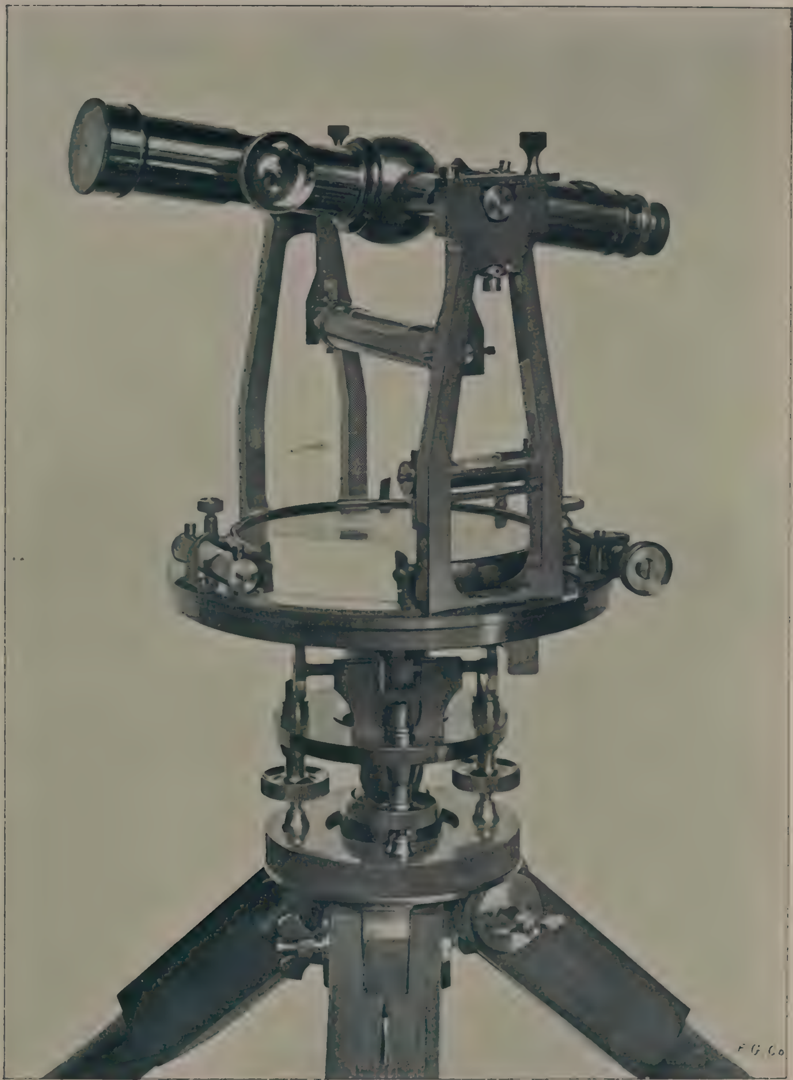
We frequently make them without the circular needle box, the advantage gained is reduced height of standards. An oblong needle box is then attached.

These instruments are sometimes made with hollow telescope axis and reflector illuminating web, on inside of telescope tube.

Y bearings.
Long centre.
Two outside verniers, reading minutes or decimals, or one minutes and one decimals.
Graduations, 6¾ inches.
Needle, 5 inches.
Tangent to plates.
Vertical adjustment to telescope.
Striding level to axis of telescope, ... $250 00

These instruments are furnished with

YOUNG'S IMPROVED EYE PIECE,
" " SLIDE PROTECTOR,
" " TANGENT,
" PATENT SHIFTING TRIPOD.



NO. 13.—TUNNEL TRANSIT

PRICE, AS SHOWN ABOVE

Needle 5 inches long, Graduations 6¾ inches, . . $250 00

For Description, see page 44.

For Extra Attachments, see page 56-A.

Centered on top of the axis of the telescope so as to be able to plumb from the roof of the Tunnel.

Young's Improved Mining Transits.

Our Mining Transits are in all essential features the same as our Engineer's Transits; the larger size corresponding to our Railway, and the smaller to our Mountain, Transits, with only such modifications necessary to adapt them to the wants of the Mining Engineer.

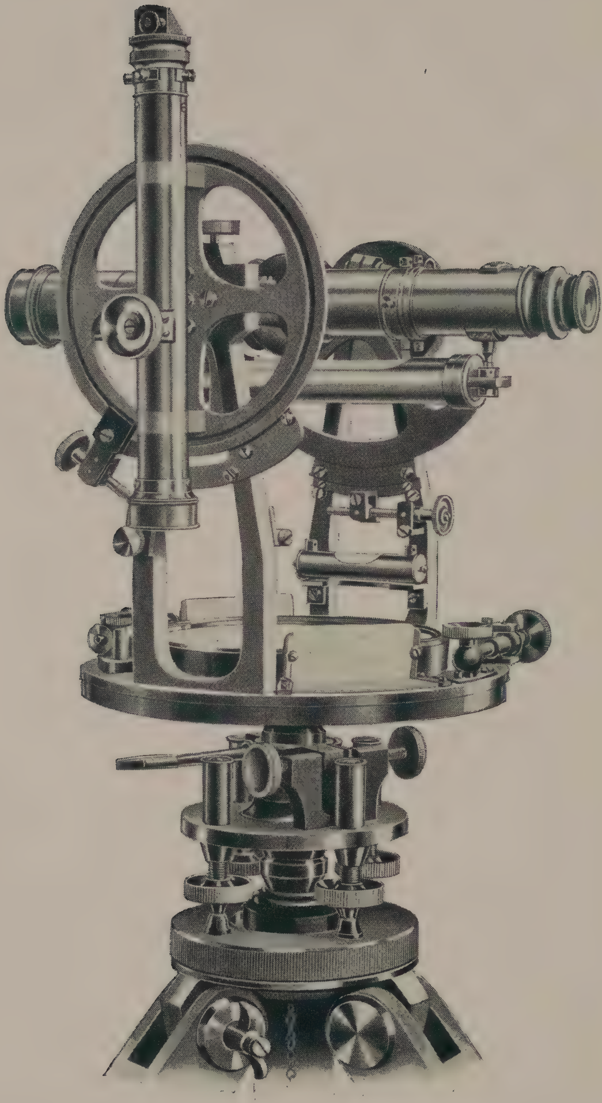
Our Improved Non-Extension Dust Proof Telescope makes a valuable addition to all Mining Transits, as it totally excludes dust, grit and foreign matter, preventing *all* wearing of the object slide, and is placed upon all Mining Transits unless otherwise ordered. **Stadia hairs,** however, **cannot be used** with these telescopes, and when it is essential that the telescope be provided with the stadia-hairs, we use the regular style telescope with improvements where the wearing of object slide is brought to a minimum and provided for.

The Graduated plates are not made from castings, but from our specially made hard-rolled and hammered plates, upon graduating engines of our own design and manufacture. The graduations themselves are sharp and distinct and numbered with two rows of inclined figures from 0 to 360, in contrary directions.

The verniers are waterproof, placed at 45° to the line of sight, are extra wide to admit light and are provided with opaque glass reflectors.

Tripods are furnished with extension legs of our own special pattern, remarkably steady. The shoes are made from Disston's rolled steel, insuring perfect fit with the leg and remaining sharp for many years.

Both Transit and Auxiliary telescopes are provided with reflector for cross-hairs and an interchangeable diagonal (prism) eye-piece.



YOUNG & SONS' IMPROVED MINING TRANSIT—NO. 1

PRICE, complete, $350 00, including clamp and opposing screws to axis of telescope ; not shown.

Young's Improved Mining Transit No. 1.

A complete Mining Engineer's Transit. Auxiliary **Side** Telescope attached to large Vertical Circle, with counterpoise. Detachable.

TRANSIT has compound long centres, needle 5 inches long; Graduations 6¾ inches, reading to single minutes; **improved** tangent to plates and opposing-piece to centre. Vertical adjustment to telescope and instrument **centered on top** of axis to telescope, and furnished with **Diagonal** (Prism) Eye-piece and **Reflector** for cross-hairs; and will focus to objects five feet distant; **Reflectors** to verniers. Level to telescope, clamp and opposing screws and Vertical Arc. Telescope with **improved** eye-piece and dust cover to object slide. Tripod with **shifting** motion and **extension** legs.

MINING ATTACHMENT.—Consisting of an Auxiliary **Side** Telescope, **Non-Extension** pattern, 7 inches long, ⅞ inch object glass, attached to a full Vertical circle, 5 inches in diameter and reading to single minutes, with counterpoise; all detachable and packed in instrument box when not in use. Auxiliary telescope revolves **independent** of Transit telescope and is provided with a **Diagonal** (prism) Eye-piece and **Reflector** for cross-hairs.

Both telescopes in these instruments are made to show objects erect unless otherwise ordered. The verniers are wide, extending to the edge of plate to allow extra amount of light, and have the advantage of being so placed that the Engineer can obtain readings without changing his position, risking disturbance of instrument.

Young's Improved Mining Transit No. 2.

A complete Mining Engineer's Transit. Auxiliary **Top** Telescope with counterpoise. Detachable.

TRANSIT. Made in **two** sizes, having compound long centres. Graduations reading to single minutes, **improved** tangent to plates and opposing-piece to centre. Vertical adjustment to telescope and **centered on top** of axis to telescope, and furnished with **Diagonal** (Prism) Eye-piece and **Reflector** for **cross-hairs.** Level to telescope, clamp and opposing-screws and Vertical Arc. Telescope with **improved** eye-piece and dust cover to object slide.

Tripod with **shifting** motion and **extension** legs.

Mining Attachment.

Consisting of an Auxiliary **Top** Telescope with counterpoise. This telescope is provided with a **Diagonal** (Prism) Eye-piece and **Reflector** for cross-hairs.

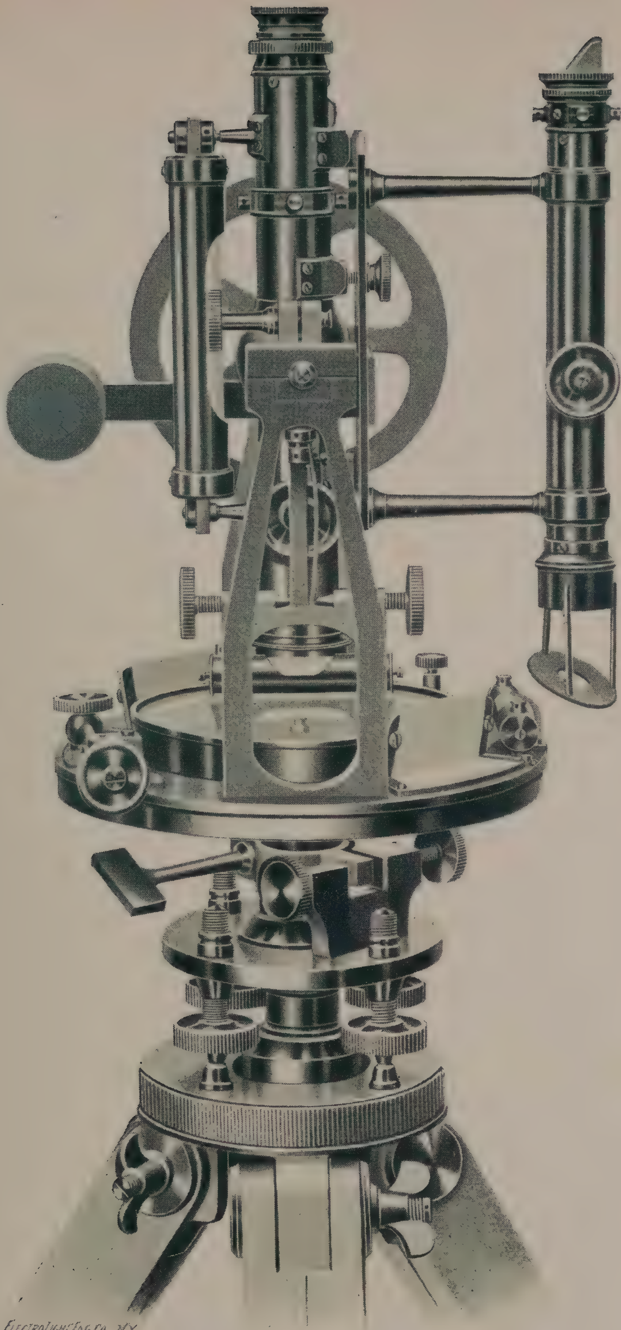
> The objection heretofore to this style of Auxiliary telescope has been owing to the method of attaching to the main telescope. When pillars were made detachable, there was difficulty in keeping the telescopes truly parallel. When pillars were attached permanently to the main telescope, they were liable to be bent and the transit was awkward to handle. By our improvement of mounting the pillars on a base and attaching to the main telescope by means of "Y" bearings, the same as used on our solar attachments to telescopes, these objections are **entirely overcome,** making this form of a Mining Transit (where an auxiliary telescope is desired) decidedly preferable.

Mining Transit No. 2

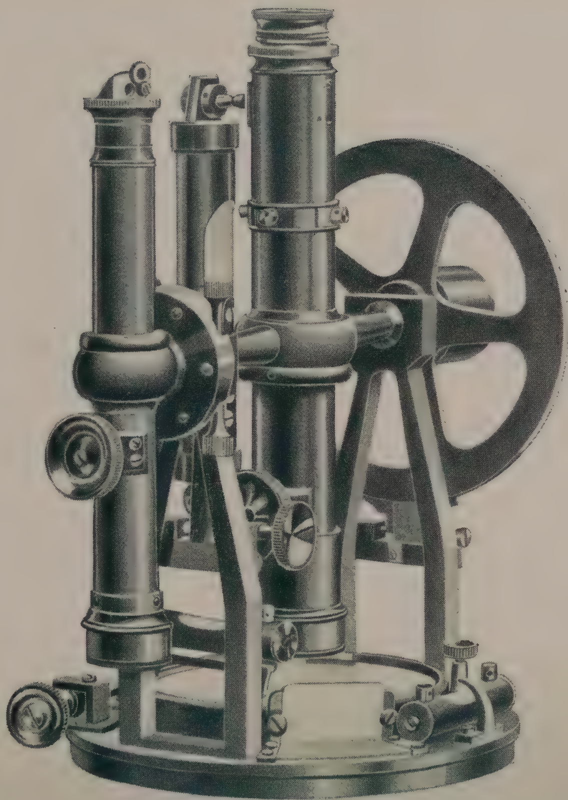
Is Made in Two Sizes.

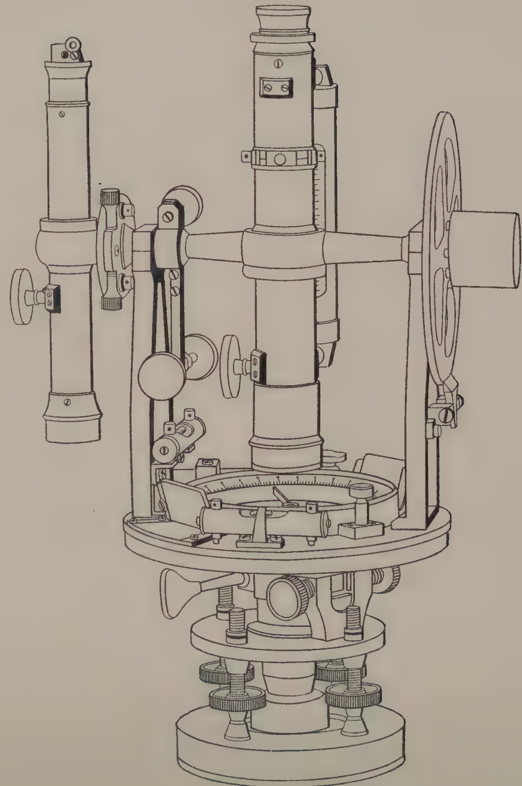
	LARGE SIZE.	SMALL SIZE.
Needle	4½ inches.	3½ inches.
Graduations	6¼ "	4¾ "
Vertical circle	5 "	4¾ "
Telescope will focus to	5 feet	5 feet
Price complete as shown in engraving	$325.00	$310.00

Both telescopes in these instruments are made to show objects erect unless otherwise ordered. The verniers are wide, extending to the edge of plate to allow extra amount of light, and have the advantage of being so placed that the Engineer can obtain readings without changing his position, risking disturbance of instrument.



YOUNG & SONS' IMPROVED MINING TRANSIT—NO. 2.





YOUNG & SONS' IMPROVED MINING TRANSIT—NO. 3

Young's Improved Mining Transit No. 3.

A complete Mining Engineer's Transit. Auxiliary **Side** Telescope with counterpoise. Detachable.

TRANSIT. Made **in two** sizes, having compound long centres. Graduations reading to single minutes, **improved** tangent to plates and opposing-piece to centre. Vertical adjustment to telescope and **centered on top** of axis to telescope, and furnished with **Diagonal** (Prism) Eye-piece and **Reflector** for cross-hair. Level to telescope, clamp and opposing-screws and Vertical Arc. Telescope with **improved** eye-piece and dust cover to object slide.

Tripod with **shifting** motion and **extension** legs.

Mining Transit No. 3

Is made in two sizes.

	LARGE SIZE.	SMALL SIZE.
Needle	4½ inches.	3½ inches.
Graduations	6¼ "	4¾ "
Vertical circle	5 "	4¾ "
Telescope will focus to	5 feet	5 feet
Price complete as shown in engraving	$325.00	$300.00

Both telescopes in these instruments are made to show objects erect unless otherwise ordered. The verniers are wide, extending to the edge of plate to allow extra amount of light, and have the advantage of being so placed that the Engineer can obtain readings without changing his position, risking disturbance of instrument.

Young's Improved Mining Transit No. 4.

The principal novelty of this Mining Transit is in the arrangement of the **Inclined Standards** by which the Engineer is enabled to range the telescope to a vertical line. The result is obtained without any **additional** telescope, while the line of collimation remains on a line passing through the centre of instrument, consequently all measured horizontal angles have their vertices over a centre point, and **no correction for offset is necessary,** avoiding the inconvenience and liability of error of double telescopes.

By means of longer centres, a light counterpoise and arrangement of details the overbalance of telescope is entirely destroyed.

The No. 4 Mining Transit is the widely known **Inclined Standard,** standing alone as the only instrument of its kind that has stood the test of time, in which the telescope can be ranged in a **Vertical Line.**

TRANSIT. Made in **two** sizes, having compound long centres. Graduations reading to single minutes, **improved** tangent to plates and opposing-piece to centre. Vertical adjustment to telescope and **centered on top** of axis to telescope, and furnished with **Diagonal** (Prism) Eye-piece and **Reflector** for **cross-hairs.** Level to telescope, clamp and opposing-screws and Vertical Arc. Telescope with **improved** eye-piece and dust cover to object slide.

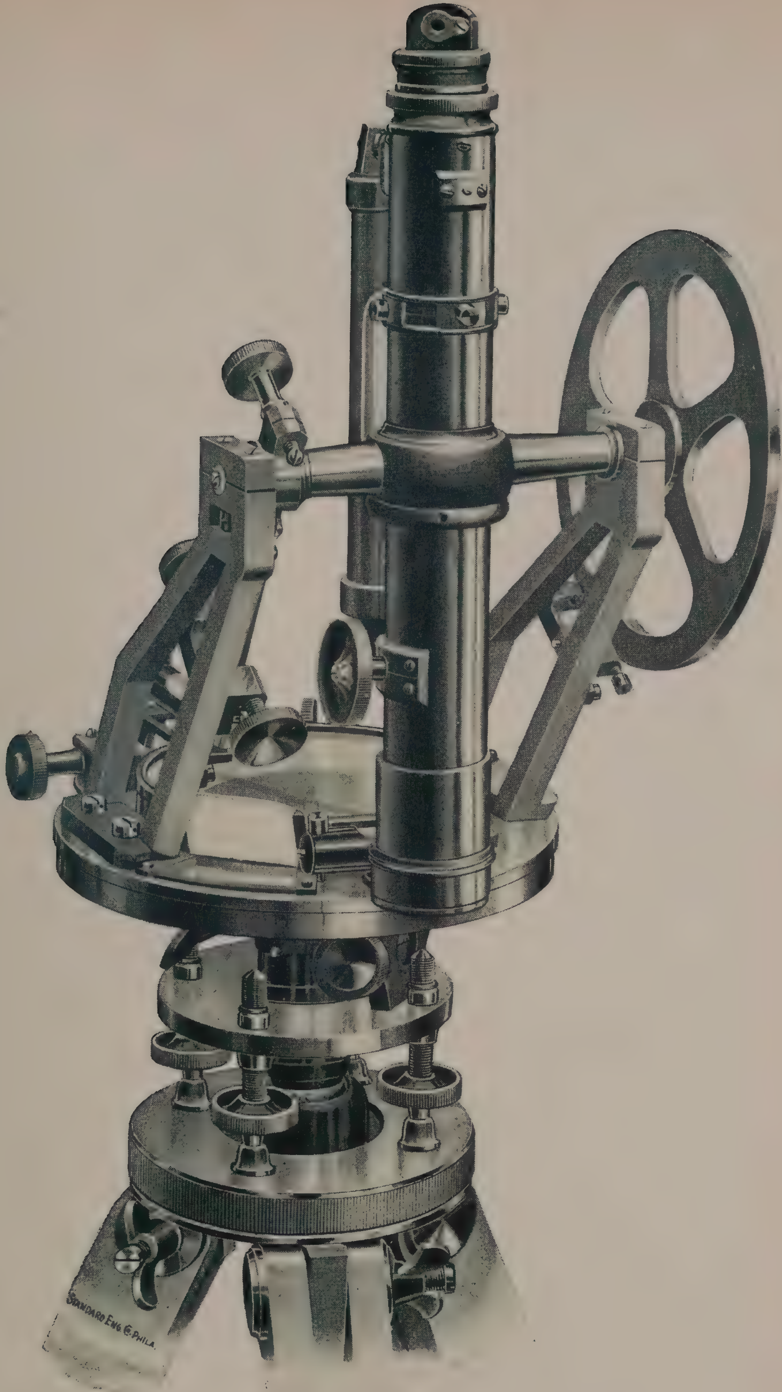
Tripod with **shifting** motion and **extension** legs.

Mining Transit No. 4

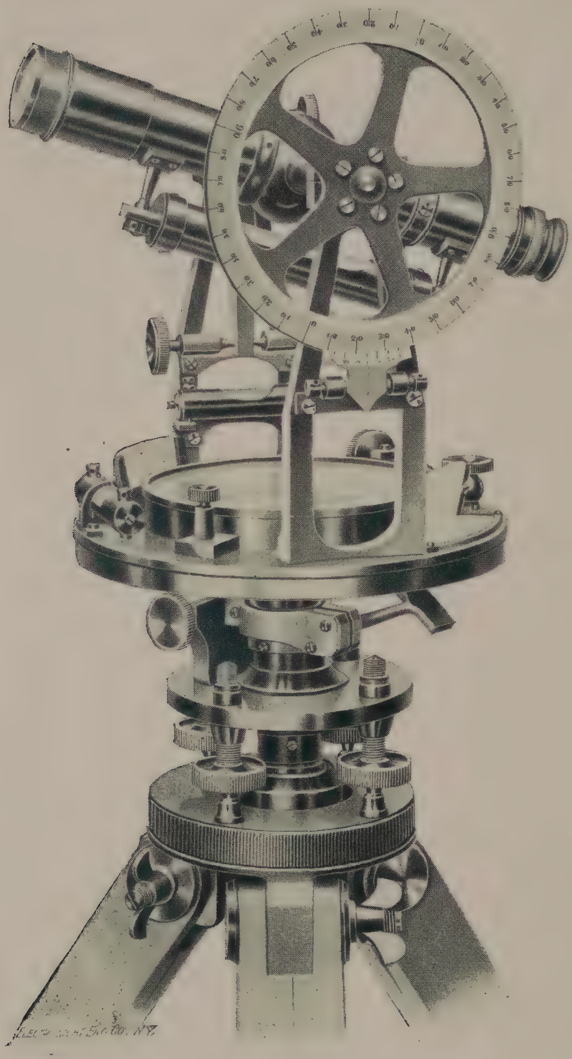
Is made in two sizes.

	LARGE SIZE.	SMALL SIZE.
Needle	4½ inches.	3½ inches.
Graduations	6¼ "	4¾ "
Vertical circle	5 "	4¾ "
Telescope will focus to	5 feet	5 feet
Price complete as shown in engraving	$280.00	$260.00

Telescopes in these instruments are made to show objects erect unless otherwise ordered. The verniers are wide, extending to the edge of plate to allow extra amount of light, and have the advantage of being so placed that the Engineer can obtain readings without changing his position, risking disturbance of instrument.



YOUNG & SONS' IMPROVED MINING TRANSIT—NO. 4



YOUNG & SONS' IMPROVED MINING TRANSIT—NO. 5

Young's Improved Mining Transit No. 5.

TRANSIT. Made in **two** sizes, having compound long centres. Graduations reading to single minutes, **improved** tangent to plates and opposing-piece to centre. Vertical adjustment to telescope and **centered on top** of axis to telescope. Level to telescope, clamp and opposing screws and Vertical Arc. Telescope with **improved** eye-piece and dust cover to object slide.

Tripod with **shifting** motion and **extension** legs.

Mining Attachment.

The telescope is provided with a **Diagonal** (Prism) Eye-piece and **Reflector** for cross-hairs.

Mining Transit No. 5

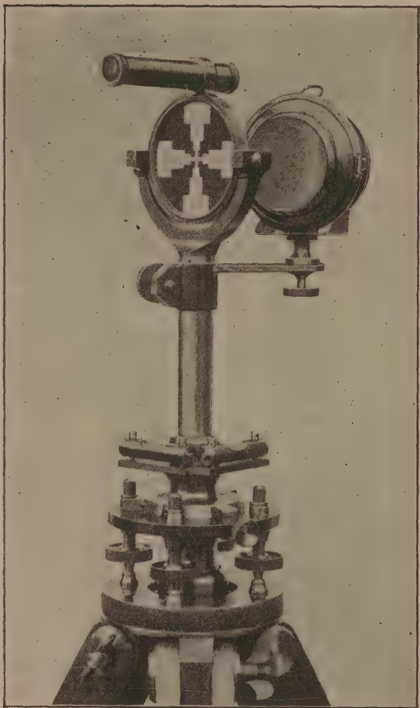
Is made in two sizes

	LARGE SIZE.	SMALL SIZE.
Needle	4½ inches.	3½ inches.
Graduations	6¼ "	4¾ "
Vertical circle	5 "	4¾ "
Telescope will focus to	5 feet	5 feet
Price complete as shown in engraving	$275.00	$255.00

Mining Transit No. 5. **Without** Diagonal Eye-piece and Reflector for cross-hairs and with 60° vertical arc in place of a vertical circle, is the Mining Transit generally selected for work in the bituminous coal regions. This style is $20 less than above prices.

Telescopes in these instruments are made to show objects erect unless otherwise ordered. The verniers are wide, extending to the edge of plate to allow extra amount of light, and have the advantage of being so placed that the Engineer can obtain readings without changing his position, risking disturbance of instrument.

Mining Transits with Lamp-Targets.



Mining Transits Numbers 1, 2, 3, 4 and 5 are furnished when so ordered, to be used with Mining Lamp-Targets, detachable above the leveling screws and interchangeable with the instrument, so that in sighting forward the Target is placed in position, the instrument taken from tripod and moved into forward tripod, while Lamp-Target is substituted on one left by instrument.

The Target is the same height as the Transit, measured from the parallel plate to the line of sight, and being provided with two spirit-levels set at right angles and having both horizontal and vertical motion, it is quickly set to the proper angle of the line of sight by means of the sight vane. The face of the Target is made of milk-white glass (on which is painted a suitable figure), and illuminated from the back by a bull's-eye lantern, which can be thrown in and out of position as desired. It is essential that lard oil be used with lamp.

As it is evident to the Engineer that the centers of the Transit and the Lamp-Targets must be fitted with that degree of accuracy as to be interchangeable, they cannot be furnished separately and it is necessary that the question of one or two Lamp-Targets must be decided at the time of placing order for Transit.

Prices.

Two Lamp-Targets, complete, with Extension Tripods,	$175 00
One Lamp-Target, complete, with Extension Tripod, .	90 00

These prices are in addition to those given for the Transit.

Additions to Mining Transits.

Extension Tripod—Young's Improved.

Legs to shorten to one-half usual length. Two clamp screws to each leg. The clamping arrangement superior and firmer to those heretofore made.

Tripod, to accompany instrument in place of regular tripod, extra, .	$10 00
Single Extension Leg to Tripod, in place of regular leg, . .	5 00
Full Extension Tripod, in addition to regular one on instrument, .	20 00

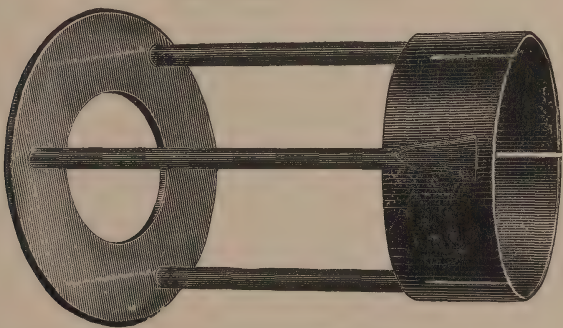
Half Length Tripod.

The usual tripod legs are halved and screwed together firmly in centre. When lower half is unscrewed, the upper presents a sharp pointed steel shoe.

The tripod is not so heavy as extension tripod, and is firmer when at full length; but is not as convenient, perhaps, in setting instrument on irregular ground.

Full Tripod, in place of regular tripod, extra, ...	$12 00
Full Tripod, in addition to regular tripod, ...	15 00

Reflector Plate.



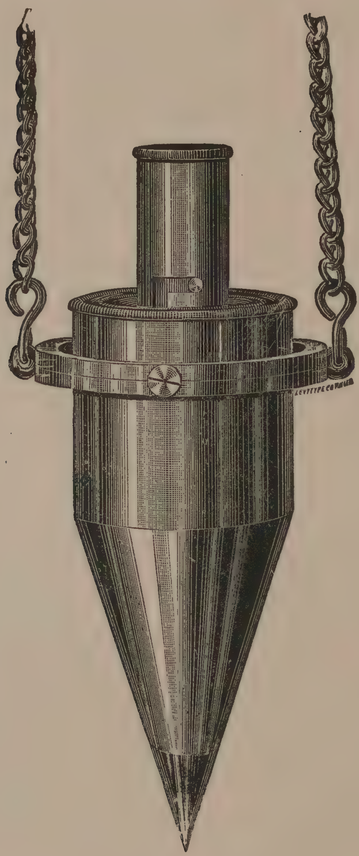
Reflector for Telescope to illuminate Cross-Hairs, ...	$4 00

Mining Tripod Lamp.

This arrangement, lately designed by us, consists of a small tripod, with shifting movement, carrying a lamp, to which a plummet is attached. This lamp is set directly over point, and can be clamped there, the legs of tripod preventing any more shifting than in instrument.

Single Tripod, ...	$22 00
Double "	40 00
With attachment to place a slit tangent in position, with lamp behind to illuminate opening, extra, each, ...	5 00

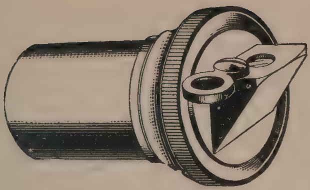
Mining Lamp and Plummet.



This Plummet is made large, with upper part hollow to receive oil and form lamp. It is suspended directly to sides by a Gimbal Ring, and hung from a point in the roof of the mines. The sight is taken to centre of flame.

Single Lamp, packed neatly in box, . . .	$13 00
Two Lamps, packed in box, ...	25 00

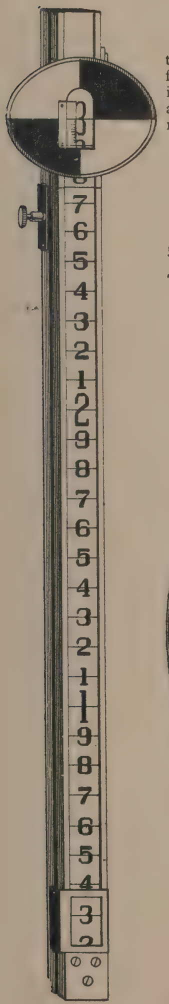
We believe the first of these Lamps in this country were made by us for Eckley B. Coxe, M. E., from drawings furnished by him.



Diagonal (Prism) Eye-Piece. $8.00.

To facilitate observations of the sun or stars for meredian, and for taking large vertical angles in mines, a plane reflector or prism is placed in an eye-piece by which the direction of the pencils of light are turned at right-angles to the eye-lens.

Such an eye-piece is called a Diagonal Eye-Piece and is highly recommended as being convenient and expeditious.



Young's Self-Reading Level Rod.

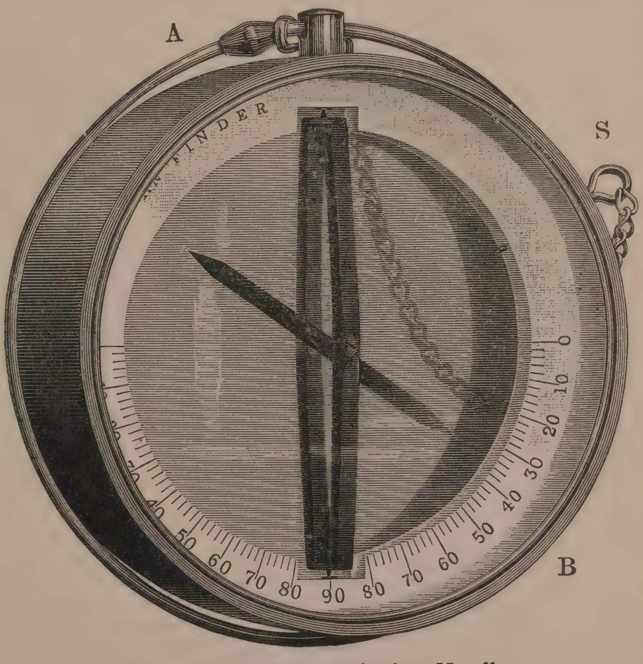
Its imitation is known as the Philadelphia. This rod, introduced by us in the early "Fifties," is a Self-Reading and Sliding Target Rod combined; all faces are *recessed* and *figures stamped*. The tenths figures are six-hundredths in size, placed central over tenths divisions, so that top and bottom of figures are exactly three-hundredths above or below, and form data by which the nearest hundredth can be read without confusion to the eye.

The Rod is 7 feet when closed, 12 feet when extended, $16.00.
For Stadia work, order an extra target . . . . 5.00.

Mining Rod.

Similar to the above, but reduced in length to 3, 4, or 5 feet, extending to 5, 7, or 9 feet.

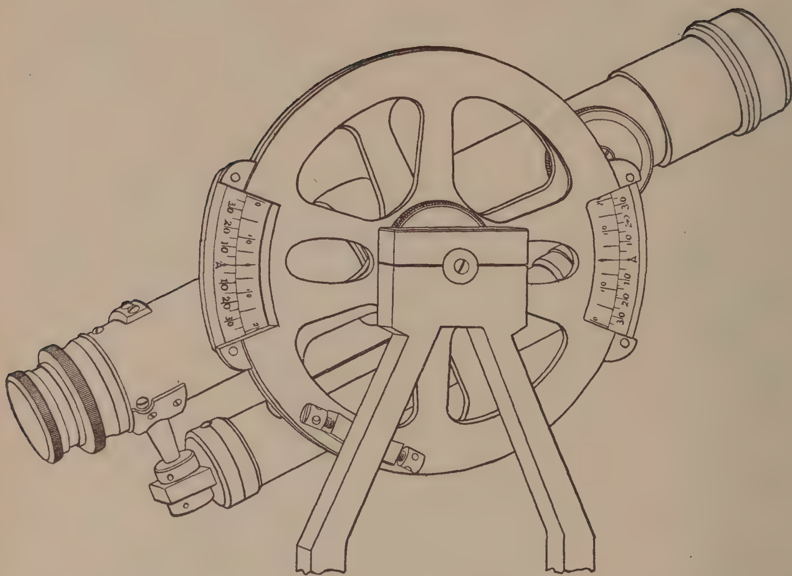
The principal difference is in target, along the center of which we cut a slit. The lamp is held behind target, and cross-wires readily subdivide this, $15.00.



Miners' Compass or Dipping Needles.

3½ inch Needle . . . . $12.00 4½ inch Needle $15.00

Vertical Arcs.



For ordinary work, we believe our 60° Vertical Arc and Swinging Vernier has no superior, and we place it upon all Transits where an Arc is desired, unless otherwise ordered. There are times, however, where a larger Arc, or even a full circle, is desirabie. For such cases, we would recommend—

A 90° Arc.—Swinging Arc, with two rows of figures, 0 to 90°, in opposite directions; with double Vernier, reading to single minutes, ... Price, $20 00

A 180° Arc.—Same as above, but numbered 0 to 90° each way from centre, ... " 20 00

A Full Vertical Circle, with double opposite Verniers, reading to single minutes, ... " 40 00

Same, with Level, ... " 50 00

Graduations on solid silver, ... " 5 00

Extra Attachments for any of the Preceding Transits.

1.	Graduations, reading 20 or 30 seconds, on plate, . . .	$10 00
2.	" " " " on vertical circle, .	5 00
3.	Vertical Arc, ...	15 00
4.	Vertical Circle, ...	18 00
5.	Level to Telescope, ...	15 00
6.	Clamp and Opposing Screws to Telescope, . . .	10 00
7.	Level to Telescope, with clamp and opposing screws, or Tangent,	25 00
8.	" " " " " and vertical arc,	40 00
9.	" " " " " " " circle,	43 00
10.	Gradienter, including Level to Telescope, ...	40 00
11.	" " " " and vertical arc, .	55 00
12.	" " " " " " circle,	58 00
13.	Stadia Hairs, fixed, ...	3 00
14.	" " adjustable, ...	10 00
15.	Diagonal Eye Piece, ...	8 00
16.	Reflector for Cross Hairs, ...	4 00
17.	" for Graduations on Plate, ...	4 00
18.	Folding Telescopic Sights, ...	8 00
19.	" " " extra long for vertical sighting in mines,	12 00
20.	Right Angle Sights, ...	5 00
21.	Variation Plate, ...	15 00
22.	Graduations on Solid Silver, except No. 7, ...	25 00
23.	Waterproof Cover for Transit or Level, ...	1 00
24.	Tripod, with three Leveling Screws, for Transits Nos. 6, 7 and 13,	20 00
25.	" " " " " for No. 1 Levels, . .	10 00
26.	Quick Leveling Tripod Head, ...	10 00

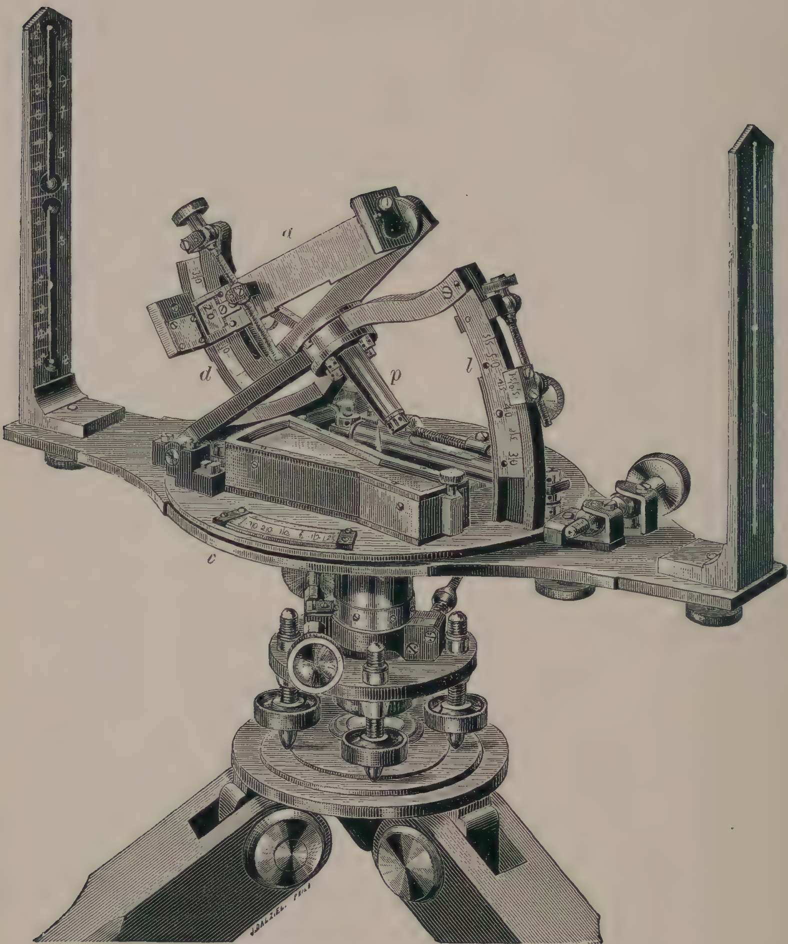
For Extension Tripods, see page 50.
" Vertical Arcs, " " 49.
" Hanging Level, " " 61.

Extras for Instruments sent for Repairs.

We make a specialty of repairing instruments of any make. Our facilities are the best, and our prices as low as consistent with good work.

Instruments must be sent to us for estimates, as we cannot, either in justice to our customer or ourselves, give any prices without an examination of the instrument.

New Cross Wires	$3 00
Reflector for Graduations on Plate	4 00
New Needle, best pattern	5 00
" Centre Pin	1 00
Adjustable Stadia Hairs	10 00
Fixed " "	3 00
Ground Glass Level for Transit Telescope	5 00
" " " " " Plate	1 25
" " " " Level Telescope	10 00
" " " " Compasses	1 00
Cap for Object Glass	75
Shade " "	75
Variation Plate	15 00
Regraduating Horizontal Plate	15 00
" Arc and Vernier	7 00
New Compass Glass	1 00
" " Sights, each	3 50
Jacob Staff Mountings	5 00
Clamp Screws for Transits or Levels	1 00
Mahogany Tripod Legs, each, $2.25; per set	6 00
Targets for Young's Self-Reading Rod	5 00
Clamp Screws for Young's Self-Reading Rod	25
Steel Shoe for Jacob Staff	75
" Shoes for Tripods, per set	1 50
Rebronzing Transit	$15 00 to 20 00
" Levels	12 00 to 15 00



YOUNG & SONS' BURT'S SOLAR COMPASS

Showing Tangent Screws to Plates, Latitude and Declination Arcs.

All Graduations on Solid Silver.

No. 19.

BURT'S SOLAR COMPASS.

This beautiful instrument, unquestionably the greatest invention in nature of instruments, deserves to be more widely known and more properly appreciated. The mineral deposits, with their local magnetic attractions, of the Lake Superior country, where it was found impossible to survey the government lands by any known method, the expense of which would not forbid its use, gave rise to the invention of Solar by Burt.

The principle consists in a practical scientific application of the principles which govern the motion of the sun, that when instrument is placed in adjustment, and the sun's image brought to a certain place, the instrument must necessarily be in the meridian. This is indicated by zeros of horizontal plates, and any other angle can be read off by graduated plates.

Solar work can only be performed in clear weather; the instrument is, however, furnished with needle and graduated plates.

As first made the Solar was without tangent screws, and with an ordinary ball and socket motion being made, in accordance with Mr. Burt's judgment, as simple as possible for use in the wooded brush country where the government surveys were then made. Since then, and with progress of surveys into more open country, the tangent screws and the transit tripod have been added.

When weather is clear the Solar Compass works with much greater rapidity than either compass or transit. With ordinary care, and instrument in adjustment, its result should not vary in rapid work more than from one to two minutes from correct line, a result unattainable in the ordinary compass, and requiring careful work to ensure in long continued lines with transit.

The original manufacturers of the Solar Compass, our forms of solar construction as designed by us, in consultation with the inventor, have stood the test of thirty years. No material change in shape or proportions have been made by the manufacturers who have attempted this work.

In these, as in our engineering instruments, we find instances where some after thirty years service are doing good work.

By a late improvement in the method of adjustment, we have secured greater accuracy than heretofore.

We make either transit tripod, which is most steady, or compound ball and socket, which works more speedily.

All graduations on silver.

Tangent to plates, declination and latitude arcs, and needle box for variation.

All arcs reading minutes, ...	$260 00
Graduations on arcs to 20 or 30 seconds, extra, ...	20 00
Solar, large size, declination and latitudes arcs 6 inches radius, readings 20 or 30 seconds, plain, ...	300 00

YOUNG SOLAR COMPASS.

PATENTED.

(PHOTOGRAPHS UPON APPLICATION.)

This Compass is the Smith Solar Attachment, mounted upon plates in the same manner as the Burt Compass. Much closer results can be obtained with this Compass than with the old form, and combined with the advantage that it will work in hazy or cloudy weather, when other Solars are useless, make it a very desirable instrument.

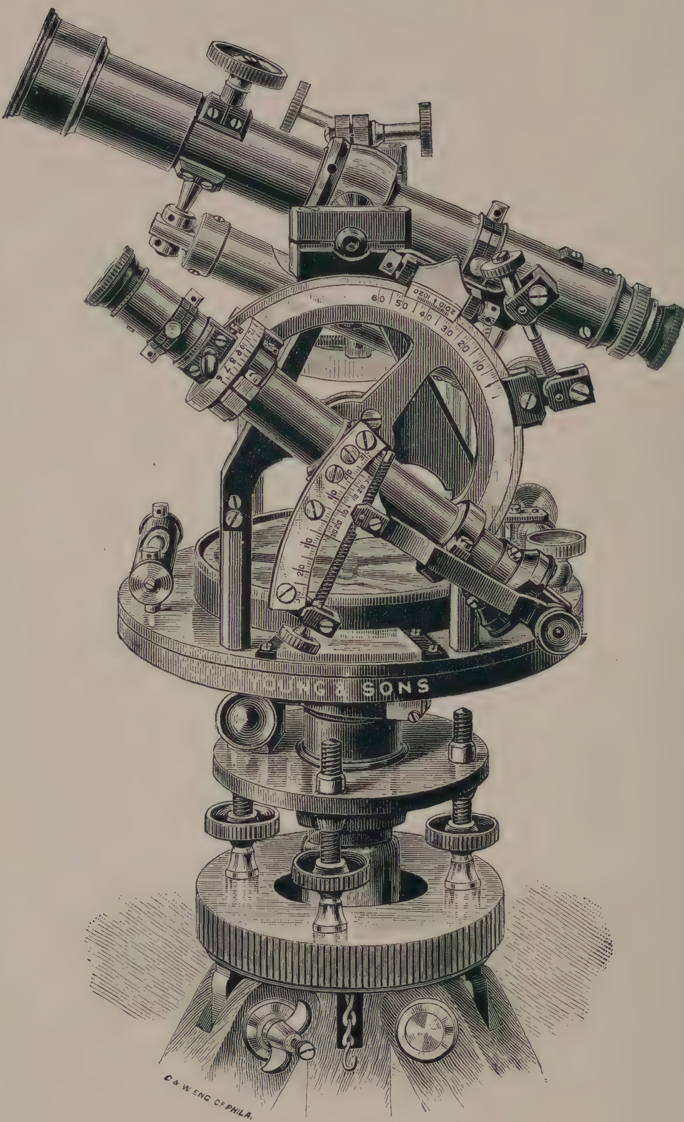
Graduations on silver.
Sights detachable.
Needle box for variation, ... $300 00

Telescope for Solar Compasses.

In both these attachments Telescopes are in line with the centre of instrument.

Telescope No. 1.—Single standard plain telescope, with the counterpoise, attaches to the end of plate same as the sights, detachable, packed in box. Price, $30.00.

Telescope No. 2.—Double standard. Level to telescope, with clamp and opposing screws and vertical arc, with counterpoise, attached to end of plates same as sights, detachable, and packed in box. Price, $75.00.



IMPROVED NO. 10 MOUNTAIN SOLAR TRANSIT

PRICE, AS SHOWN ABOVE

Needle $3\frac{1}{2}$ in., Graduations $4\frac{3}{4}$ in.	$285 00
With variation plate, ...	300 00

For Description, see page 59.

For Extra Attachments, see page 56-A.

SOLAR TRANSITS.

We have added to the list of our instruments the Solar Attachment of Benj. H. Smith, C. E., to which the attention of Engineers and Surveyors, especially those engaged on government surveys, is called.

The distinctive feature of this Attachment consists in the use of a Reflector, moved by a declination arm, whereby the sun's image is reflected into the focus of a short telescope, the axis of which corresponds to the polar axis of other forms of Solar Attachments.

The compactness of this form of Solar especially adapts it for attachments to transit instruments, with the ordinary workings of which there is no interference. No counter-poise is required.

The clear limb of the sun's image can be brought between the equatorial wires with greater exactness than can be attained by the ordinary plan of focussing on a silver plate and hence the meridianal result is more accurate.

The polar axis, the vital part of a Solar, is longer than in any other form.

Another great advantage which has been experienced by those using this instrument is the facility with which the sun's image can be taken in hazy weather, when the old forms of Solar cannot be used.

For the use of U. S. Deputy Surveyors, we recommend our No. 10, or Mountain Transit, as suitable for this Attachment.

PRICES.

No. 10 Transit, 3½ inch needle, 4¾ inch graduations, extension tripod, level to telescope, with tangent screw or opposing screws, vertical arc, Smith Solar Attachment,	$285 00
Same, with variation plate,	300 00
Solar Attachment to No. 6 or 7 Transit,	80 00

Solar Attachment

UPON THE

TELESCOPE.

We now place the Smith Solar upon Telescopes of Transits, which are already provided with Level to Telescope and Vertical Arcs The direct latitude being read from the arc or circle. This Attachment makes the lightest and most accurate Solar yet introduced. Detachable, and packed in box with the instrument.

PRICE,

attached to any of our instruments,

$60.00.

We can also place this Solar upon an instrument of any make, at a slight additional cost.

PHOTOGRAPHS UPON APPLICATION.

THE HANGING LEVEL.

A CROSS-LEVEL, NOT PERMANENTLY ATTACHED TO THE AXIS OF TELESCOPE, BUT IS ADJUSTED AND FITTED STRIDENT WITHOUT CLAMP, READILY REVERSIBLE AND REMOVED FROM INSTRUMENT IN PACKING.

For Transits with horizontal Vernier reading to single minutes, the ordinary plate levels are sufficiently accurate to insure good results. For graduations reading 30 seconds, or finer, we would recommend the Hanging Level. This level, which is ground as sensitive as the level attached to the telescope, not only insures a perfect leveling of the horizontal plates, but tests the motion of the telescope in a vertical plane.

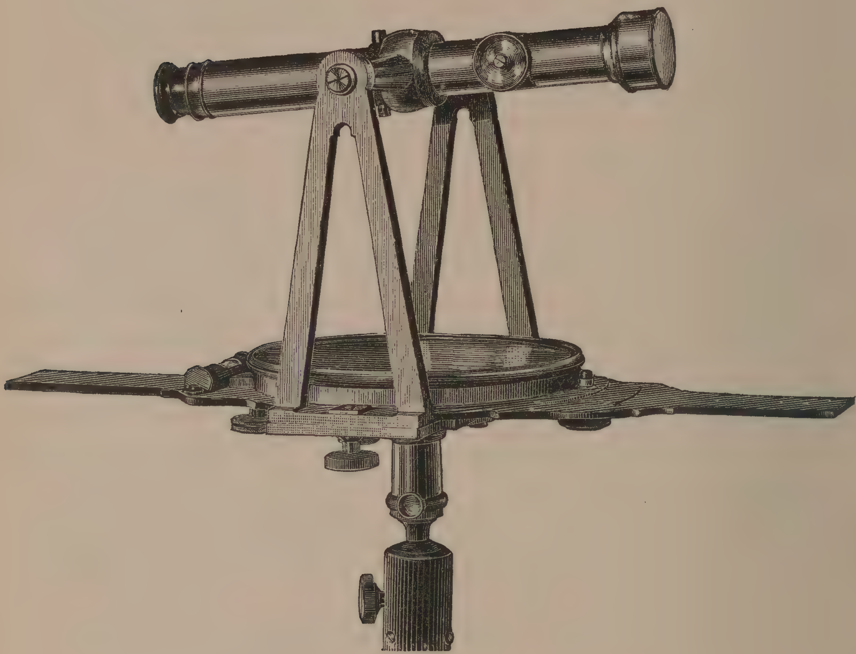
It is suspended from collars of equal diameter on the axis of telescope, and is furnished with our Nos. 7 and 13 Transits.

Price, attached to other Transits, $20.00.

Adjustment of Hanging Level.

Level the Instrument and clamp the plates, with the telescope over one pair of leveling screws. Hang the level on the axis of telescope, and notice the position of the bubble—if not in the centre of divisions, bring it there by means of leveling screws. Remove level, and reversing it end for end, replace it; and if the bubble does not take the same position, correct it, one half by means of leveling screws, and the balance by means of two capstan head screws, at end of level, working in a perpendicular direction; repeat this operation until the correction is made. Now swing the level slightly on its bearings, and notice if the bubble retains its position in centre of divisions; if not, correct by means of two capstan head screws at the other end of level, working in a horizontal direction. If this correction has to be made, it will be necessary to go over the first part of the adjustment, to see that it is still correct.

Telescopic Attachments for Compasses.



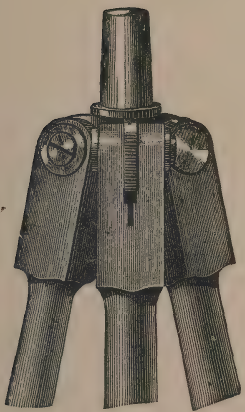
The above engraving represents our New Telescope Attachment for Compasses. It is attached by fastening a brass plate to the under side of the Compass, allowing the ends to project about one-fourth of an inch beyond the plate on the side, by which the standards and telescope are held in position by a clamp screw and steady pins.

The advantage of this Attachment is, that the telescope is always in adjustment and directly over the centre of the instrument.

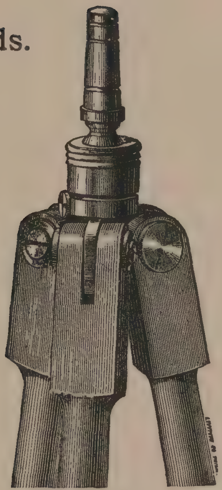
Compass can be used with either the sights or telescope.

Price, attached to any Compass, ...	$30 00
Same, with level to telescope, vertical arc, clamp and opposing screws, ...	50 00

Compass Tripods.

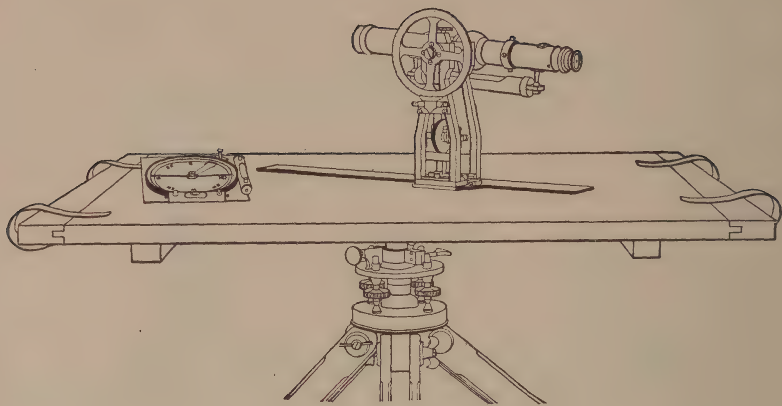


No. 1.



No. 2.

Compass Tripod, No. 1, as shown in engraving,	. . . . .	$6 00
" " " 2, without ball-spindle,	. . . . . .	7 00
" " " 2, with " as shown in engraving,		8 50
" " " 3, with ball and socket and leveling screws,		18 00
" " " 4, with leveling screws, clamp and tangent,		20 00



Plane Tables.

Our complete Plane Table comprises every improvement. The smaller size will be found light and convenient; while the larger, more substantial and heavier.

No. 1.—Board 30 x 28 inches, in carrying case with handles. Provided with paper clamps, plumbing bar and plummet, compass needle with square base and two straight levels, engineer's level tripod head with four leveling screws, clamp and tangent movement.

Alidade with Telescope, power 22 to 24, all improvements. Fixed Stadia Hairs, level to telescope, Clamp and Opposing Screws and full Vertical Circle $200.00

No. 2.—Board 30 x 28 inches, in carrying case with handles. Provided with paper clamps, plumbing bar and plummet, compass needle with square base and two straight levels. Improved tripod head, large base with leveling screws, clamp and tangent movement.

Alidade with Telescope, power 24 to 26, all improvements. Gradienter, including level to telescope and full Vertical Circle $300.00

Young's Self-Reading Level Rod.

This rod, as introduced by us 22 years ago, is by its merits gradually superseding all other rods.

All the faces are recessed and painted clear white. The figures are stamped deeply and then painted, so that they will not rub off. The feet are painted red, the tenths black. The latter figures are six hundredths in size, placed by gauge, generally over centre of tenth division, so that the top and bottom of figure indicates exactly three hundredths above or below. By this arrangement it has been found the top and bottom form data by which on fair distances the hundredth can, without confusion to the eye, easily be read. Placing them central over divisions enables the nearest tenth, for surface levels, to be more easily read. When preferred these figures can be placed with bottom on line.

The rod is 7 feet long, and when readings are desired above this, it slides up and forms a continuous self-reading rod to 12 feet.

The target when used above 7 feet comes against a stop, so that the error arising from this reading being wrong, or of being knocked from its correct reading without discovery, so common in all other rods, is avoided.

In addition to the self-reading characteristic, it is equally a Sliding Target Rod.

By combination of the two qualities the Engineer is enabled in target readings to give the rodman the reading of rod to nearest hundredth at once, so that exact reading may be obtained in one or two shiftings, as well as to know whether any error exceeding one or two hundredths has been made by rodman.

For rapidity of readings on surface levels, for checking the rodman on turning points, and on more accurate readings, we believe it superior to all other forms. Cross section and similar work on railroading can be performed with at least twice the rapidity and with much greater certainty, besides relieving both the instrument man and rodman of much exhausting irritating labor.

Lately we have introduced several improvements in the mountings, by which the rod is made more durable.

Price, ... $16 00

New York Level Rod, Best Pattern, . . . $16 00

Boston Level Rod, ... 16 00

TRANSIT SIGHT POLES.

Made of well seasoned ash, octagonal, with long steel pointed shoes. Every precaution taken to ensure rod remaining straight. Pole divided into feet, and colored red and white alternately.

Transit Poles, 8 feet, flat or octagon, ...	$3 00
" " 10 feet, flat or octagon, ...	3 50

HAND LEVELS.

These little instruments, five inches long by one inch in diameter, intended for reconnoissance, and numerous instances where approximate levels are desired, is held in the hand, the reflected image of bubble brought over wire in tube, and line of level carried out by the eye.

Lock's Hand Level, German silver, in case, ...	$10 00
" " " brass, in case, ...	9 00
Abney Level and Clinometer, combines Lock's Level with Clinometer, giving angles of elevation and depression, in wooden box, ...	15 00

SLOPE LEVELS.

Mining Pattern.

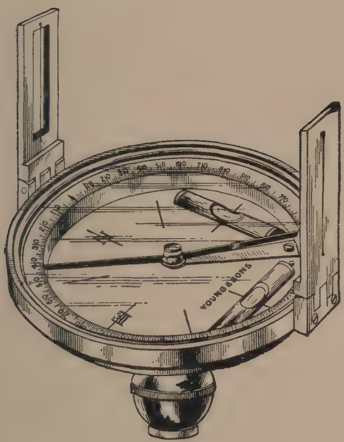
Square. Packed in strong wooden box.

4 inch square, ...	$10 00
4½ inch square, ...	12 00

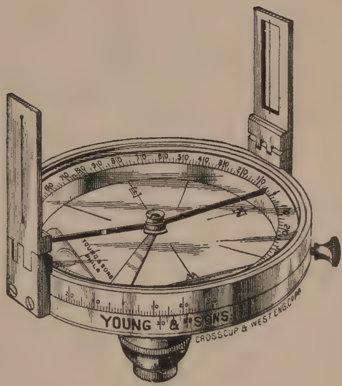
Engineer's Pattern.

Base 8 inches long, folds into box 2½ inches wide, . . .	$12 00

POCKET SURVEYING COMPASSES.



POCKET COMPASS, NO. 2.



POCKET COMPASS, NO. 3.

Pocket Compasses.

1.	Pocket Compass, 3½ inch needle, Jacob staff mountings, folding sights,	$12 00
2.	Same as above, with two straight levels,	13 50
3.	Pocket Compass, 3½ inch needle, folding sights, Jacob staff mountings, with two straight levels and variation plate,	16 00
4.	Same as No. 3, but with needle 4½ inches long,	18 00
5.	Small Extension Tripod for Pocket Compasses,	5 00
6.	Leveling Screws for any of the above,	5 00
7.	Clamp and Tangent for Spindal,	5 00
8.	Small 9 inch Telescope,	5 00

ENGINEERS' POCKET RULES.

Pocket Rules for Engineers, divided on one side to feet and tenths and hundredths of feet; on reverse side to feet and inches.

Two feet, four fold, by mail to any address, . 50 cents.

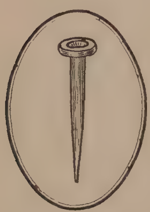
ENGINEERS' AND SURVEYORS' CRAYON FOR MARKING STAKES.

Made in four colors:—Red, Yellow, Blue and Black.

Box of one dozen sticks, all of one color, or assorted colors, .	60 cents.
Postage on box, ...	10 "
Sample by mail, ...	10 "

Made specially for us, to meet the demand for a good crayon.

Colors all bright. Will mark any kind of surface, wet or dry, and will not rub off.



THE ENGINEERS' AND SURVEYORS' STAKE TACKS.

This ingenious little arrangement is simply the common tack, with an indenture in head to receive the pcint of the sight pole.

The Engineers' Club, of Philadelphia, says of it: "Thus another, although trifling, source of error may be eliminated."

PRICES.

Prismatic Azimuth Compasses.

Prismatic Compass, Needle Card of Aluminum, 3½ inches, folding prism and hair sight, metal cover; in sole leather case, $25 00

Prismatic Compass, 3 inch, with azimuth glasses, consisting of colored screen glasses and mirror attached, respectively, to folding prism and hair sight, floating card compass ring divided to ½°, and metal cover; in sole leather sling-case, 35 00

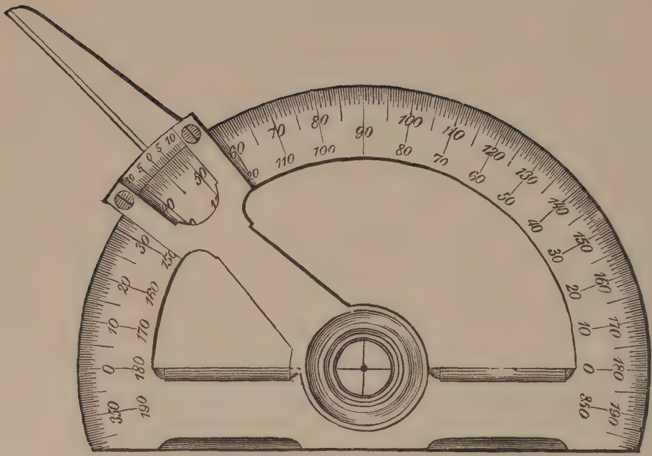
PROTRACTORS.

Cleaver Protractor.

The protractor can be used, being placed on one end, on a board eight feet long, without shifting, and when shifted can, by means of adjusting screws, be placed exactly upon line.

It works, especially when many angles are wanted, with rapidity. It is used almost exclusively in mining regions of Pennsylvania.

5¾ inch square, 4 inch circle, clamp and tangent, two double verniers, graduations on silver, ...	$45 00
6¾ inch square, 5 inch circle, ...	50 00
10½ " " 9 " "	85 00



The Swiss Arm Protractor.

Semicircular protractor, German silver, horn centre, 6 inches diameter; arm, 3 minutes,	$11 00
8 inches diameter; arm, 1 minute,	14 00
10 " " " 1 "	18 00
Whole circle protractor, 6 inches diameter; arm, 3 minutes,	14 50
" " " 8 " " " 1 minute,	16 00
" " " 10 " " " 1 "	20 00

German Silver Protractors, with Arms.

Protractor, ½ Circle ½ Degrees, with Arm and Horn Centre, 5 inches diameter, each	$6 50
Protractor, ½ Circle ½ Degrees, with Arm and Horn Centre, 6 inches diameter, each	7 50
Protractor, ½ Circle ½ Degrees, with Arm and Horn Centre, 7 inches diameter, each	9 00
Protractor, ½ Circle ½ Degrees, with Arm and Horn Centre, 8 inches diameter, each	11 00
Whole Circle ½ Degrees, Arm and Horn Centre, 5 inches diameter, each	10 00
Whole Circle ½ Degrees, Arm and Horn Centre, 6 inches diameter, each	12 00

Steel Blade Protractor.

Shifting Head.

This form is used on drawing boards, the edge of protractor resting against edge of board, and the steel blade carrying vernier arm—being moveable to any angle. While edge of board remains straight, this forms a rapid and comparatively accurate method of protracting. Heads are made larger than usual (9 inches), so that any irregularity in edges of board will have less effect.

The accuracy of the work is much increased if an extra steel straight edge is fastened along edge of board, so the head of protractor will work upon this edge. These straight edges are then readily fastened to the board with screws.

Protractor 4½ inches diameter, 36 inches blade, divided to half degrees, ... $14 00

Rolling Parallel Rule.

Edges bevelled in contrary directions. Two inches wide.

12 inches long,	$12 00
14 " "	14 00
15 " "	15 00
18 " "	18 00
24 " "	25 00
Morocco or wooden cases,	2 75

Pocket Sextants.

Brass, with cover, which unscrews and forms handle to hold instrument; telescope, reading glass, rack and pinion movement, capable of measuring angles accurately. Graduations on silver.

Price, ... $50 00

YOUNG'S CHAIN TAPE.

The universal satisfaction given by these Tapes for several years past warrants us in bringing them more prominently to the attention of Engineers and Surveyors. They are narrow bands of steel ribbon, 1/8 of an inch wide, and are made in lengths of 33 to 1,000 feet, either with or without joints. Graduations are marked by *riveting* a small brass sleeve to tape.

The Chain Tape is capable of general use in surveys of all character, and especially in the rough preliminary and location of Railroad work. The increased accuracy of results, particularly in measurements on curves, has been a surprise to Engineers using them; the one beneficial result of closer agreement in measurements, before and after construction, is alone sufficient to recommend them.

Where subdivisions of foot to inches or tenths are desired, for lengths of 100 feet or under, it is advisable to use the Chesterman or Paine Tape, our object in the Chain Tape being to furnish one that will stand rougher usage, as well as one that can be used for longer distances.

They are all marked by United States Standard, made by us and compared at Office of Weights and Measures, at Washington, and the temperature at which they are compared stamped upon them, and means of adjustment for temperature, for whole lengths, furnished if desired.

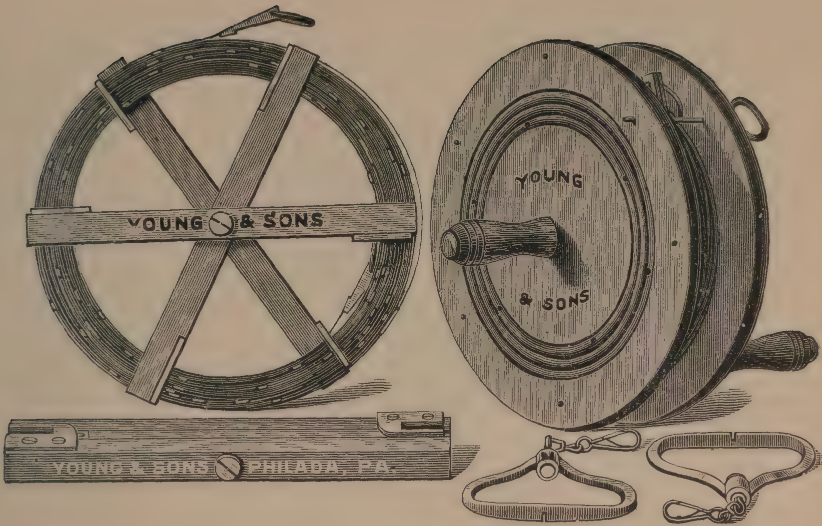
The Tape can be conveniently wound up by making a single turn at one end, and tying this end and the coil tightly together so they cannot slip, and then coiling up by hand. An ordinary chain handle, slit so as to catch in any part of the chain instantly, is used for stretching for short distances.

We do not place the temperature adjustment on chain unless ordered. These adjustments, as usually made, only correct for entire lengths, and leave intermediate lengths in error, especially in measuring for short distances from corrected end. It is preferable to correct by calculation.

Expansion for each lineal foot for 1° is .000072 of an inch.

A 100 feet Tape expands, for each 10°, one inch in 1,400 feet.

The temperature of test being stamped on our Tapes, the correction can be made.



PRICES.

100 feet Tapes, marked every ten feet, ...	$4 00
100 " " " chain style, in feet, ...	8 00
50 " " " " " "	4 50
66 " " " " " in links, ...	7 00
33 " " " " " "	4 00
Additional length, per 100 feet, graduated in feet, ...	5 00
" " " " every 10 feet, . . .	2 00
Reel for Tape, which closes so as to be placed in pocket, for 100 feet or less, ...	2 00
Winding Reel for lengths over 100 feet, according to size, from $2 50 to	5 00

Extra markers, and material, with directions for mending, accompany every Tape.

These Tapes can be sent by mail at following rates:—

Folding Reel, without tape, . . .	15 cents.
100 feet Tape, without reel, . . .	30 "
100 " " with reel, ...	45 "
200 " " without reel, . . .	55 "
300 " " without reel, . . .	65 "

400 feet Tape weighs over four pounds, and cannot be sent by mail.

Winding Reels cannot be sent by mail.

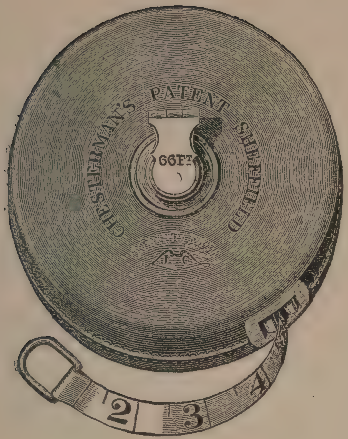
CHAINS.

Steel Chains.

SUPERIOR BEST TEMPERED STEEL. OUR OWN MAKE.

50 feet,	No. 12	wire, oval links, brazed,	$ 6 00
100 "	No. 12	" " " "	11 50
50 "	No. 12	" " " not brazed,	4 50
100 "	No. 12	" " " " "	8 00
2 pole,	No. 12	" " " " "	3 50
4 "	No. 12	" " " " "	6 50
2 "	No. 12	" " " brazed,	5 50
4 "	No. 12	" " " "	10 00
10 meters,	No. 12	" " " "	5 50
20 "	No. 12	" " " "	10 00
10 vara,	No. 12	" " " "	5 50
20 "	No. 12	" " " "	10 00
10 meters,	No. 12	" " " not brazed,	4 00
20 "	No. 12	" " " " "	7 00
10 vara,	No. 12	" " " " "	4 00
20 "	No. 12	" " " " "	7 00

Steel Chain Pins.



Chesterman's Metallic Tapes.

These Tapes have fine brass wire running lengthways through linen tape to strengthen and counteract the effects of dampness.

Metallic Tapes.	24 feet long, 10th or inches, Folding Handle,	.	$1 80
	33 " " " " " "	.	2 10
	40 " " " " " "	.	2 35
	50 " " " " " "	.	2 50
	66 " " " " " "	.	3 00
	75 " " " " " "	.	3 30
	100 " " " " " "	.	4 50
	50 " " " " Flush Handle,	.	3 25
	100 " " " " " "	.	5 00

Chesterman's Metallic Tapes, without Boxes.

33 ft., $1.50. 50 ft., $1.75. 66 ft., $2.00. 100 ft., $3.25.

Metallic Tape divided in feet and 10ths on one side and centimeters and meters on the other.

50 ft., $3.75. 100 ft., $6.00.

Chesterman's Steel Tapes.

Steel Tapes.	10 feet long, 10th or inches, German Silver Case, .	$3 25
	10 " " divided on one side to inches and on the other side to centimeters and millimeters, .	3 50
	25 feet long, 10th or inches, Flush Handles, . .	5 00
	33 " " " " " " . .	5 75
	40 " " " " " " . .	6 75
	50 " " " " " " . .	7 00
	66 " " " " " " . .	9 00
	75 " " " " " " . .	11 00
	100 " " " " " " . .	14 00
	50 " " " " extra wide and heavy, .	13 00

Steel Tape Measures divided into 10ths of a foot on one side, millimeters and meters on the other,—

50 ft. long, $8.50.   100 ft. long, $16.00.

Steel Tape Measures, 20 meters long, divided into millimeters and meters, ... $9 00

Steel Tape Measures, German silver, in case, spring and stop, 10th or inches,—

3 ft., $1.50.   4 ft., $2.00.   5 ft., $2.25.   6 ft., $2.50.

Steel Tape Measures, divided on one side to inches, and on the other side to centimeters and millimeters,—

3 ft. long, $1.75. 4 ft. long, $2.25. 5 ft. long, $2.50. 6 ft. long, $2.75.

Linen Tape Measures, silver plated case, spring and stop,—

3 ft. long, 50 cts.   6 ft. long, $1.00.

Paine Patent Steel Tape.

This is a narrow ribbon tape, occupying a larger box than the Chesterman, not so highly tempered nor so liable to break. It occupies an intermediate place between Chesterman's and our Chain-Tape.

Japanned case, folding handles, 10ths or inches,—

25 ft., $3.50.	50 ft., $6.00.	75 ft., $10.00.
33 " 4.50.	66 " 8.00.	100 " 12.00.

Leather Case, flush Handles,—

33 ft., $5.50.	66 ft., $10.00.	100 ft., $15.00.
50 " 8.00.	75 " 12.00.	

Extras to Paine Tape.

Handles, with graduated scale for temperature, .	per pair,	$4 50
Pocket Thermometer, ...		1 50
Spring Balance and Level, ...		5 00

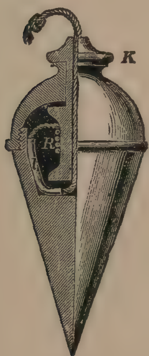
Plummets.

No. 1.

No. 2.

No. 3.

Plummet No. 1, weight 10 oz.,	. . . .	$2 50
" " 2, " 15 "	. . . .	2 50
" " 3, " 3 pounds, for plumbing down deep shafts,		4 00



No. 4.

No. 5.

Adjustable Plummet, No. 4, weight 8 oz.,	. . . . . .	$2 50
" " " 5, " 8 "	. . . . . .	1 75
" " " 5, " 13 "	. . . . . .	2 25
Plummet Cord, per yard,	. . . .	06

Invention and Introduction of Engineer's Transit.

The first Transit instrument was made during year 1831. It was a long stride in the improvement of Engineering instruments; and that it should to-day retain its almost identical first form, proves the value of its introduction and the good judgment of the inventor.

The English Theodolite, capable of performing the same work, found, if we are to credit the traditions of earlier members of the Engineering profession, but little favor with the American Engineers. Its workings were slow and inconvenient. Few cared to trust the prolongation of a straight line by reversing the Theodolite on its centre, and trusting to the vernier readings; and as few fancied the trouble of reversing telescope on its Y bearings, "end for end." Forgetfulness in fastening of clips resulted in fall of telescope, while if clips were too tight there was the danger of shifting the instrument in fastening, or if too loose the telescope rattled. Such were some of the discomforts attending use of the Theodolite, an instrument well fitted for many purposes, and whose peculiar merits still cause many of our English brethren to cling to its use.

From the Theodolite the change was to the Magnetic Compass. This, in its simplest form, or in its modified form made to read full circle angles independent of needle, was high in favor with many, especially those Surveyors who, from their local knowledge, (and some with naught besides), were selected to "run" the preliminary lines of railroads. By dint of labor, these Surveyors mastered the intricacies of the vernier, but could never be brought to doubt the superior virtues of compass-sights in seeing past a tree or other obstruction. With the transit the tree had to come down; they would not undertake to say the staff on other side of tree was in line of cross web, but were sure they could make it "just right" with the line of sights. Nevertheless, though frequently doing close work, the needle would play pranks that produced much trouble; and though to be commended for speed on the preliminary, was rather too uncertain for location.

In the year 1831, the first Transit was made by William J. Young. It was graduated to read by vernier to 3 minutes, it being in early days a favorite idea of inventor that graduations of 3 minutes could be easily read to one minute, and was less perplexing to use. The instrument had an out-keeper for tallying the outs of the chain, and a universal or round level. The needle was about 5 inches; the telescope 9 inches, of low power. The standards were of almost identical pattern now used by some makers. The centre between plates was of flat style, vernier on inside of needle ring, and the plates moved upon each other by rack and pinion. The plates and telescope detached from tripod, fastened, we believe, when attached, by a snap-dragon, as in later instruments.

THE FIRST AMERICAN TRANSIT

Invented and introduced by YOUNG & SONS, of Philadelphia, in 1831.

For whom the first Transit was made, the records, as far as we can find them, do not positively show; as well as it can be gathered from them, and from other data, the first one was used on the State works of Pennsylvania, but whether on the Mountain Division or on the Inclined Plane of Columbia R. R., is uncertain.

The distinguished Engineers of the Baltimore and Ohio R. R. also claim the use of the first Transit; and as illustrative of their belief, we append the following extract from RAILROAD JOURNAL of December, 1855:

"The Transit is now in common use in this country, and is a comparatively cheap instrument. Such, however, is not the case in Europe. In England, the old mode is still in vogue, to a great extent, of laying out curves with the use of Ordinates; we are not sure, indeed, that any other course is not an exception."

"Some years since, Mr. Charles P. Manning, an accomplished American Engineer,—now the efficient Chief of the Alexandria, Loudoun and Hampshire Railroad,—went to Ireland, and on the Limerick and Waterford Railway, initiated the method, so common in this country, of laying out curves with the Transit."

"The first instrument of this name was made by Mr. William J. Young, the accomplished Mathematical Instrument Maker, of Philadelphia, for the Baltimore and Ohio Railroad Company, the Engineers of which made the first suggestions modifying the old Theodolite. We have in times past used this instrument, which is much like those made at the present time by the same manufacturer, and is, if we are not mistaken, still in the field."

"Since then, Transits have been little improved, but have been changed in the wrong direction. They are generally much heavier than formerly, containing as much brass and mahogany as one man can well stand under. This great weight is not only useless, but dangerous. Heavy instruments are much more liable than light ones to get out of adjustment on transportation—even in the ordinary field service. They are not a whit steadier in the wind; being generally made with clumsy tripods and large plates, they expose a greater area to the breeze. *If the feet of the tripod be firmly planted*, the instrument is rarely disturbed by the wind. Besides this, a heavy instrument is much more liable to danger from accident in a rough country."

And the following, from same Journal of January 5, 1856:

THE FIRST TRANSIT COMPASS.

"In our issue of the 15th of December, 1855, in noticing the field book of C. E. Cross, C. E., we took occasion to state some facts concerning the first Transit Compass, an instrument made by Young, of Philadelphia. We have since then received an interesting letter from Mr. Charles P. Manning, whom we mentioned as having initiated in Ireland the American method of laying out curves. Mr. Manning disclaims the honor in favor of 'Richard B. Osborne, Esq., an Engineer who received his professional

education in the service of the Reading Railroad Company, under Messrs. Moncure and Wirt Robinson (where he finally occupied the responsible position of Chief of the Engineer Department, during the early struggles of that Corporation, in its competition with its rival, the Schuylkill Navigation Company), and from which road he went to Ireland, and took charge of the location and construction of the Waterford and Limerick Railway in 1846.'

"Mr. Manning says further: 'I obtained from Mr. Young, and sent to Ireland, probably, the first Transit Compass ever known in that country or in England; and soon afterwards joined Mr. Osborne as his Principal Assistant, for the purpose of aiding him in the effectual introduction, at least upon that road, of the American system of location and construction.'

"We were familiar with these facts when we made the statement which Mr. Manning desires corrected. But our object was not so much to mention the party to whom the credit of introduction was due, as to state a few facts immediately connected with the history of the instrument. Mr. Osborne introduced the instrument into Ireland, Mr. Manning initiated its use among the junior assistants.

"'Mr. Osborne was the first to construct an Iron Bridge upon the plan of Howe's Patent Truss—several of which he put upon the W. & L. Railway; and, I believe, he also built and placed upon the same road, the first eight-wheeled, double-truck passenger and freight cars (American plan) that were ever used in Great Britain.'

"Mr. Manning gives us a very entertaining sketch of the history of that first Transit, made by Young, of which we remarked that we had in times past made use.

"'Twenty and odd years ago—when a mere boy—I saw that instrument upon a lawyer's table, and afterwards in a court-room—a dumb witness in behalf of the patentee. Nineteen years ago, after considerable service in tracing the centre line of the Washington Branch of the B. & O. R. R., it was used in making surveys for the extension of the last named road, westward from Harper's Ferry, and your humble servant carried and used it at that time in Washington County, Maryland, and in Ohio County, Virginia.

"'In the last seven years the instrument accompanied me as a duplicate, and was occasionally used upon the location and construction of the B. & O. R. R., through the wilderness, west of Cumberland, and now rests upon its laurels in the office of the Baltimore and Ohio R. R. Co. in Baltimore.

"'It was *instrumental* in setting the first peg that was driven for the extension of the B. & O. R. R. west of Harper's Ferry; and it was 'hard by,' and able to do duty, when the last peg was set for completing the track of that road upon the banks of the Ohio river.

"'In all material points Mr. Young has never been able to improve upon this original work of his hand, but in some of its minor parts he has effected desirable changes—such as the tangent screws connected with the clamp of the tripod—the substitution of a clamp and tangent screw for the old rack and pinion movement of the two compass plates—the subdivision of degrees into minutes, by an improved graduation of the vernier, &c., &c.

"'The original instrument had an index for counting the number of deflections made at one sitting; also a small bubble upon the exterior of the telescope, for the purpose of defining a horizontal line, without resorting to the aid of its companion, the ordinary Level,—but these superfluities were soon thrown aside; and one of its peculiar features was, and is, a Vernier, graduated only to *three* minutes.'"

Mr. Manning but expresses the facts when he says, that in all *material* points but little change has taken place. The changes that have taken place, have been those called for by peculiar circumstances—modifications, which, while retaining the characteristics of the Transit, have approached more nearly to the peculiarities of the Theodolite. Transits in after years became divided into the two distinct classes, FLAT CENTRE, as first introduced, and LONG CENTRE, with centres as previously used on Theodolite; but it was not for many years that the long centre—for accurate work the best construction—became other than the exception. It now is the rule, and the flat centre the exception.

Engineers of the present day, unaware of the actual difference in these two styles, and unacquainted with the circumstances of early introduction of instrument, are apt to treat the flat centre with a disrespect it is far from deserving.

For the same strength, the flat centres are far the lightest. Says an experienced and competent Engineer to us, within the few days past, "The first requisite of a Transit is lightness and portability." Judged by these requisites, the Flat centre is the instrument of to-day. But he spoke for his own peculiar branch—railways; and while we are by no means ready to endorse this opinion, we have no hesitation in saying that the circumstances existing at the time of first use of Transit were such, that had the instrument been constructed with the long centre, its usefulness and general introduction would have been very much retarded. The great peculiarity of the first made Transits was their ability to stand hard usage, and non-liability to get out of order under ordinary usage. The centre is a broad metal plate—thick, which it is impossible to bend, or injure in any manner, except by wear; the plates were thick, not easily bent, and the spring vernier, in case of bending of plates, followed their motions and allowed the readings to be made sufficiently accurate to continue work. The rack and pinion had nothing that could break, while the tangents, as then constructed, were equally simple. If the standards, by a fall, were bent so that the telescope would not revolve in a vertical plane, the construction was such, that with the axe as a screw driver, the standards could be loosened, and a piece of paper inserted to correct them.

"In fact, the opinion of the writer, with means of observation, and the use of such an instrument, is: *That a flat centered Transit, rack and pinion, and spring vernier, cannot be made totally useless by any accident short of absolute breakage of parts.*

Not so, however, with the long centre. There, the least injury to centres or plates ends the usefulness of the instrument for its work, and it can stand comparatively little rough usage without receiving this injury.

Of the good judgment of the first form of construction, the length of time that many of them have been in use—for some are still doing duty—is the best of evidence. Twenty-five years ago, as rodman, we followed and worked with a flat centre Transit, that to us then looked old enough to retire upon its laurels. So constant had been its use, that its corners, of hard hammered brass, the edges of its standards, and other parts, had then been rounded in carrying against clothing. Ten years afterwards we followed behind it, on the location of one of our main lines across the mountains, where, for a long time, it had been the sole available instrument; and one year ago it was in the shop for repairs, the owner still believing that for Railway work it had no superior. This instrument was light, weighing between fifteen and sixteen lbs.; had seen at least 40 years' service, large part of the time in the hands of Assistants, and in rough, wooded country. We doubt the possibility of a long centred instrument leading an equally long life.

While in charge of some Railway works, we kept in office, where there were several Assistants, both styles of instruments, and the Assistant's choice, in all cases, was for the flat centre.

It is not our intention to argue any superiority in the first form of Transit. It is not the equal, for accuracy and smoothness of motion, of the long centre. Its day of universal application has passed, and its field of usefulness narrowed; but it yet *has* its field, and the Engineer will do well in making selections to give it fair considerations. Our desire is simply to do it justice, and to offer for it a slight defence to our younger Engineers, who, having never seen or used it, can know but little of its faults or merits.

In the Transit's early days, no Express, on call, drove to the door, receipted for the boxes, and relieved all anxiety, no matter how many thousand miles away, nor what obscure point was the destination. Instead of this, they had in many cases to be consigned to the top of the stage, or to the Connestoga wagon, unless the destination was near the coast, when the sea became the best route. Thus we find the following extracts, looking at random into the books of shipment:

1833. Aug. 13. Sent, per ship Chester, to F. Beaumont, Natchez, care of Florchell & Co., New Orleans.

1833. Aug. 16. Sent, per brig Mohawk, to Boston, to W. G. Neil, for Boston and Providence R. R.

There is no difficulty in understanding why the call was for a Transit that nothing much short of entire annihilation would render necessary to send back, over its slow, long and uncertain journey, for repairs.

The spread of Internal Improvements in this country had, at this time, fairly commenced, and with it the demand for the new instrument increased rapidly. So great was this increase, and so much did it outgrow the facilities of manufacture, that the inventor was compelled to send to England an order to have the greater part of a limited number of transits made. This was in 1835, and these were the first Transits, or parts of Transits, made in

England. About three dozen were thus obtained, the more particular parts being made here. They proved far from remunerative; some few were passable, others more troublesome, requiring alterations and repairs; while a fatal fault to a needle instrument, iron in the metal, was found to exist in nearly a dozen.

Of the latter, most were broken up; several remained in the establishment, in an unfinished condition, until recently, one of the last being taken to adorn the monument of a Civil Engineer, in Laurel Hill Cemetery, Philadelphia.

The earlier manufacture of the Transit instrument was, for want of conveniences, attended with many difficulties. The art of Graduation had as yet made but little progress, and the introduction of the Transit called for nearer approach to perfection. The first Graduating machines were extremely primitive, consisting simply of a circular plate of about 18 inches diameter, upon which degrees and half degrees were marked off, either by mechanical sub-divisions, or from a similar plate. The one in the establishment of W. J. Young, bears the name of ADAMS, Maker, LONDON, and consists of such a plate as we have described.

Such were the means of graduation in 1820. Mr. Young started, as soon as he commenced business, the construction of an engine of 24 inches diameter, worked by the endless screw and treadle; and shortly after introduction of Transit commenced another of 26 inches diameter, for finer work, in which a new and important principle of construction for these engines was introduced. A few years afterwards, this same machine was rendered Automatic, and is yet doing active duty, second to none outside of the establishment for accuracy. About the same time, Mr. Edmund Draper constructed a graduating engine, which, amongst those acquainted with it, has a high reputation for accuracy.

The completion of the large 48 inch Graduating Engine, by W. J. Young, which he intended to be the perfect engine of the world, completed a line of Graduating Engines, which, for completeness of range, is certainly not equalled here, perhaps not in any establishment in Europe.

As Transits advanced to perfection, these advances in graduation became necessary. That they were not made at once, but were the result of almost a life of thought, work and patience, and source of expense, is evident from the fact, that from the year 1821 to 1860, or but 10 years before his death, W. J. Young was almost constantly engaged upon the making or perfection of these engines.

Another serious difficulty arose from want of opticians of ability. The first glasses used were imported principally from England. With the slow communication across ocean at that period, it was long before an order given could be received; and the purchase of all glasses to be found here, of proper size and focal length, furnished but a short supply. What was more troublesome, was the next supply differed in size and length from the last. When an inquiry for a larger instrument, or one of different construction, came, the question which determined the practicability of its manufacture, was the capability of making the telescope.

About 1849, an optician named Worth, commenced in New York the manufacture of glasses of telescopes for Engineers' Instruments, and they proving so much better than those otherwise obtainable, the writer of this was sent to learn, under Worth's instructions, the optical art. Before long, arrangements were made, Mr. Young purchased the tools and machinery, and it was removed to Philadelphia, along with the workmen, and connected with his establishment, with which it continued connected for many years, until, from increasing business, the tax on personal attention became too onerous; the tools and machinery were retained, and Mr. Worth placed in position to start for himself. From the optical department, as carried on during this period, came the majority of those now engaged in the manufacture of glasses for Engineering instruments. It gave the impetus which established the business permanently in this country. Fitz, of New York, and one or two others, had been quite successful in making the larger glasses for Astronomical Telescopes, but we believe had not turned their attention to the others.

The Transit instrument having thus been brought nearer perfection, in graduation and optical performance, received but few more changes in construction. The decimal graduation of vernier, suggested at an early day, by S. W. Mifflin, C. E., proved great advantage in the turning off deflection angles for curves, and was adopted by many, notably by the Engineers of Pennsylvania R. R., all of whose instruments were graduated in that manner.

The *loose* vernier and arc, for vertical angles, applied by the writer, about year 1850, was an improvement over the much liable to be injured full circle.

The Shifting Staff-head, patented by W. J Young, in 1858, was another of those little improvements which increase the value of instrument much.

The many varied uses to which, from progress of science in this country, the instrument has been called, has brought forth instruments of greater delicacy and different constructions, until, to-day, the finest Transit of the conscientious instrument maker is a splendid instrument, not surpassed in its performances by the production of any other country.

Of later minor improvements, some beneficial, some the exploded humbugs of by-gone days, we are not now to speak. The profession have other, perhaps less partial means of discovering them. Our desire is simply to keep from oblivion, the dates and circumstances of introduction of the instrument which has played so important a part in the ever memorable forty-five years of American Railroad construction, and which might, perhaps, be lost in the whirl which has been crowding the Railroad mind ever forward, leaving it no time to look back to the earlier laborers.

Adjustments
of
Engineers' Instruments.

The Principles, the Methods and the Performance.

Written especially for this catalogue.

We will endeavor to so illustrate the general principles, that after their careful consideration the Engineer will never be at a loss to apply proper correction, will be enabled to test his instrument understandingly and adjust them confidently, without being confused in attempt to follow the directions generally given.

A consideration of the principles of adjustments tells us that, independent of the verniers and of needle, (which consist in placing certain points in straight line, and perhaps should not be classed as adjustments) they all consist in placing certain parts either at right angles or parallel to each other.

Thus, the adjustment of Transit consists in making the plates, or which we here consider the same, the spirit levels, revolve at right angles to vertical centre of instrument; in making the axis upon which telescope turns, at right angles to same centre, or parallel with plates; and in placing the line of collimation at right angles to this last; and if we include the comparative position of web, it would be in placing the vertical web at right angles to this same axis.

Again, in the Level, the adjustment in like manner consists in placing the line of collimation and the line of level parallel to each other and at right angles to the vertical axis upon which instrument revolves.

In making these adjustments the spirit level acts an important part; but we have here chosen to consider it merely as means of making them, or of placing the instrument in position.

The general method made use of is that of reversions. Reversions double all errors and place them on opposite sides, so that if there is no difference after reversals there is no error; or if there is a difference, the mean between the two points indicates the amount of errors as well as the true point. *Every* adjustment may be set down as depending upon the method of *reversals.*

In the following directions we shall first give the *object* of adjustment and then the general method of performing it.

OF THE TRANSIT.

The adjustment of Transit, disregarding the needle and centre pin, are:—

1. The Levels.
2. The Standards.
3. The Telescope,
   And where the telescope has a level attached.
4. The Telescope Level,
   And where there is a vertical circle.
5. The Zero of Vertical Circle.

OF LEVELS TO COMPASSES, TRANSITS, &c.

The **object** of this adjustment is to bring the levels in such position that the bubbles will remain in centre of tube in all positions of instrument, when the vertical axis of instrument is in a true vertical position, or in other words, to bring the "level" at right angles to vertical axis of instrument.

The **method** is to bring the bubble in centre of tube, then reversing the instrument on its vertical centre, the bubble in tube will pass over double the actual distance indicating its error—changing it half way back by adjusting nuts and half by levelling screws.

To **perform** adjustment, bring bubble in centre of level tube by means of levelling screws; turn instrument half way on its vertical centre. If the bubble moves to one end, bring it back half way, as nearly as can be estimated, by means of the capstan nuts or screws under the ends; and the remaining half by means of the instrument levelling screws. The trial should then be repeated by another turning half way round and similar correction.

If, as is general, there are two levels at right angles, it is preferable to adjust one approximately and then the other, as well as to turn the instrument as exactly half way round as possible.

Should one level be much out it is difficult to adjust other, as turning it more or less than half way causes it to partake of the error of the level which is out, and the adjuster will be making corrections for errors which do not exist, and placing his levels more out instead of in adjustment.

When adjustment is completed by reversing in several positions upon one centre, the reversal should be tested upon the other centre or plate. If the centres are not true to each other, or the plates at right angles to both centres, the level on reversing on different plates will not remain in centre, and indicates an error which the Engineer cannot correct.

We suppose in this, as in other cases, the Engineer will readily perceive and understand the means provided in the instrument for making the necessary changes, and that he will not injure the threads of his screws and peril the permanency of his adjustments by overstraining, but in all cases bring nuts and screws to simply a firm bearing.

OF THE STANDARDS.

The **object** of this adjustment is to bring the bearings upon which telescope revolves at right angles to vertical axis of instrument, in order that the telescope may move in a true vertical plane when this axis is truly vertical.

The **method** generally employed is to compare the line as described by motion of intersection of web upon any two marks, such as top and bottom of building, when instrument is in one position, with line described by same, when instrument and telescope are reversed.

Another method is to test the motion of intersection of web on a plummet string. This last is, however, more of a test upon accuracy of two adjustments, this and the levels, and on account of short distance at which a plummet line must be placed, in order to give sufficient vertical angle, and the unsteadiness of lower end of line, it is not regarded by us as the best. It is of advantage, however, to test by all methods.

While in this adjustment it is as well to have instrument at level, it is not necessary. The adjustment can be as accurately performed in any other position, and it will be found most convenient to throw instrument into such position as to command well defined marks above and below.

To **perform** adjustment, select a building or other object which, with instrument at distance of at least 40 or 50 feet, will give a vertical range as great as instrument admits of observing. Any well defined mark or spot on top of high building will answer. Direct the intersection of cross-wires of telescope to this mark, clamping all plates and centres of instrument firmly, then depress telescope and select or make a mark where intersection of web strikes; reverse the instrument on centres, which will cause telescope to point the other way, and reverse telescope to former direction, bringing intersection of web to bear upon upper mark, then depress telescope to lower mark. Should it not correspond with this lower mark, a point half way between it and where the intersection now strikes is the correct line, and the adjustment should be so altered as to cause the telescope to travel on this line. As in other adjustments the reversals should be tried several times.

ON LINE OF COLLIMATION.

This is generally termed the adjustment of cross-webs. The **object** is to bring the optical axis of telescope at right angles to the axis upon which telescope revolves. As the setting of the telescope on the axis must necessarily be quite accurately performed by the instrument maker, there is left for the Engineer only the bringing of the cross-web, by which the line of telescope is defined, into the line of collimation.

The **method** employed is, in principle, obtaining a straight line passing through centre of instrument, and comparing with it the line produced by a revolution of telescope on its axis. The two means generally employed are: first, by comparing the line given by a revolution of telescope on its axis, or by back and fore sight when axis is in one position with the

line, as given by revolution of telescope, or back and fore sight when axis has been reversed. It is evident that with same back sight the reversal will give an error equal in amount, but on opposite sides, on the two fore sights; hence the true line is one from back sight passing through centre of instrument and a point midway between the two fore sights. The cross-web is then drawn over until it is one-fourth the distance between the two fore sights, or one-half the distance between the back sight and the proper line midway between the two fore sights.

It is a frequent error with Engineers to draw the cross-webs over one-half distance instead of one-fourth. The reason the correction should be only one-fourth is because of its doubling itself,—equally on the fore sight as on the back.

The second method consists in producing a straight line by a single fore sight marking two ends and an intermediate point, placing the instrument on the intermediate point and adjusting to the two ends.

To **perform** adjustment by first method, set the intersection of cross-web upon back sight, stake or other mark, and clamping plates and centres, revolve telescope on its axis; mark point where the intersection strikes. Reverse instrument on its vertical axis, bring intersection to bear on back sight, and revolve telescope on its axis, and mark this fore sight along side of former one.

Measure and mark midway between these two, also midway between this last and the last fore sight. The first midway mark is the one on straight line passing through back sight and centre of instrument. The second, or one one-fourth between the two fore sights, is the one to which the cross-web of telescope should be made to correspond, in order to bring the web to proper place. Therefore, without changing instrument, bring the intersection of cross-webs, by means of the capstan screws, to act upon this last midway mark. This done, it is advisable to remove the marks except the one midway between the two fore sights. If the adjustment has been correctly made the intersection of webs will strike upon the back and fore sights alike when instrument is reversed on centre.

If, as may often happen, the back and fore sights are inaccessible, the difference of one-fourth must be made by estimate, and perfect adjustment obtained by repeated trials.

In making these adjustments the back and fore sights should, if possible, be equal, to avoid changing focus of telescope; but, as a test after adjustment is complete, the telescope should be thrown out or in, and then brought to its proper place and adjustment tested to ascertain if this motion of telescope causes any change in line of sight. We would not advise the length of sights to exceed 300 feet; it will be found a closer adjustment can be made at this than at longer distances.

To **perform** adjustment by second method, place points under centre of instrument—one at about 500 feet distant, and by instrument, one in line midway between. Set the instrument over centre point, bring intersection of web upon one of the end points, and revolve telescope upon axis and mark where it strikes opposite the other end point; measure and

mark midway between these two points, and without changing instrument, move cross-web upon this midway mark. Then test by reversing instrument upon its vertical axis, sighting at one extremity and revolving telescope upon its axis upon the other, as before.

Previous or subsequent to this adjustment, as Engineer may prefer, the cross-web should be set vertical, so that it will remain upon object as telescope is raised or depressed at upper or lower edge. The most convenient way is to sight to object on upper edge, and raise telescope until it comes in lower edge of field. If web does not strike, loosen web screws, and turn slightly either by hand or by tapping slightly on screws.

If the web is set before performing the last adjustment it must be examined at the close, as adjusting is liable to throw it out.

OF LEVEL TO TELESCOPE.

The **object** is to bring level parallel to horizontal optical axis of telescope.

The **method** by which it is performed depends upon principle, that from any point equal angles of elevation or depression for equal distances will result in equal difference of elevation or depression from this point, and that two points equally above or below any other point must be of equal height or level with each other. Two points on a level are thus obtained, and if instrument is set over one at an ascertained height, the level line as given by instrument, if in adjustment, will strike at same height above other, or the difference of readings will measure amount of error.

To **perform** adjustment the instrument is carefully levelled, equal distances measured in line on opposite sides, and with level on telescope in centre of tube stakes A and B, driven to an equal reading below instrument. These two must then necessarily be upon a level with each other. The instrument is then moved say 10 feet beyond one of the stakes, say A, in line with other; a rod reading taken with level upon A, and this reading with correction, as below, held on B and level altered so as to strike the rod on B will complete adjustment.

If the instrument was directly over A, and its height above A ascertained; it would only be necessary to hold the same height or reading on B; but as this height cannot be correctly ascertained except by reading through instrument, it becomes necessary to move away from stake, and in observation this distance partakes of error of instrument and needs the correction, which is proportionate to distance of instrument and stakes from each other.

The rule for correction, when the instrument is beyond stakes is:

Divide the difference of readings on stakes, by distance between stakes, and multiply by distance from instrument to further stake.

Thus, if difference of readings is 2 feet, distance between stake 200 feet, and distance of instrument beyond 10 feet, then

$$\frac{2.}{200} \times 210 = 2.1, \text{ amount of correction.}$$

Should the instrument be placed *between* the stakes, in place of beyond, double the error of distance from instrument to nearest stake takes effect, and the rule becomes:

Divide the difference of readings on stakes, by the difference of distances from instrument to each stake, and multiply by distance of instrument from furthest stake.

Thus, distances same as before, except instrument being placed between stakes, 10 feet from one, then the difference of readings would be 1.8, and

$$\frac{1.8}{190 - 10} \times 190 = 1.9, \text{ amount of correction.}$$

Another **method** by which this adjustment may be performed is by the **Gauss method** of using the Y level as a collimator.

The level to be so used must be in adjustment, levelled accurately and focused on a distant object, to secure parallel rays.

To **perform** this adjustment. Set up the collimator, with a lamp or candle back of the eye end of telescope, with a piece of white paper between, to illuminate the cross-hairs.

Set up the Transit at any convenient short distance of ten or twelve feet from the collimator, pointing into the object glass of same, with the optical axis of the two instruments nearly coincident. Level the Transit accurately by means of the level under the telescope. Make the horizontal hair of the Transit coincide with the horizontal hair of collimator by means of tangent screw to the vertical circle, adjust level to centre of divisions by means of the nuts under the level. In making this adjustment it is not necessary that the optical axis of the two telescopes should *exactly* coincide, only that they should nearly coincide.

OF ZERO OF VERTICAL CIRCLE.

The **object** is to bring zero of vernier circle to agree when the level is in true level line and the vertical axis of instrument in a true vertical one, or that when either axis or level are correct the other shall be at right angles to it.

The **method** is by bringing level on middle and reversing on vertical centre. The amount the level is out on reversing indicates double error, which must be equally corrected on the bubble by its screws and on centre by levelling screws, and vernier then set to agree with zero of circle.

To **perform** adjustment, level instrument by ordinary levels, then bring the bubble of telescope level to centre and reverse on vertical centre. Correct half of amount of disturbance of bubble by means of tangent or opposing screws and other half by means of parallel plate screws. When the instrument is so the bubble remains stationary in reversing instrument on centres, the zero's vernier must be shifted to read

zero, if possible, if not, the reading noticed as a constant to be added or subtracted.

OF THE LEVEL INSTRUMENT.

The main objects in adjustment of Level instrument are to place the line of collimation parallel to level line, and the vertical centre at right angles thereto.

The adjustments are:

1. Telescope or Line of Collimation.
2. Of the Level.
3. Of Bar or Y's, which in reality is the adjustment of relative position of the telescope and level to vertical centre.

1.—OF TELESCOPE OR LINE OF COLLIMATION.

The **object** of this adjustment is to bring the cross-web on line of collimation.

The **method** by which it is performed is by revolving upon the telescope collars and bringing the cross-web into centre of revolution.

To **perform** it the telescope is brought to bear upon a distant object, plainly visible, by means of the levelling screws, instrument clamped, and telescope is then revolved half way round on the collars; the distance the cross-web strikes from the point is double error, and the web must be brought half way over by means of capstan head screws, moving the web in opposite way to which it apparently has to go.

The operation may be made with the vertical and horizontal webs at same time, or each may be adjusted separate. When adjusted for a long distance they should be tested on short one, say 15 feet.*

2.—OF LEVEL TUBE.

The **object** of this adjustment, after first is performed, is to place the level in such position that when bubble is in centre, a tangent to the curve at its highest point will be parallel to the line of collimation.†

The adjustment is, in fact, a combination of two—of the main one and of the side adjustment to tube—that the axis of telescope and of level

* If adjustment does not hold good, the slide of telescope does not work parallel with line of collimation and the only remedy is in instrument maker. The means of adjustment to the slide to obviate its error we have always found a greater source of disturbance than of benefit, the constant working of slide upon movable adjusting ring loosens the screws, and the tube has nothing whatever but a loose ring to direct its motion.

† This adjustment does not follow because when level is reversed, the bubble remains in centre, an error into which we believe all the best books have fallen. We use the Y bearings, so to speak, as a plane or point, and whilst reversals make certain the level is parallel thereto, it does determine the same of collimation, as the collars of telescope upon which revolution is made may be of unequal size and not affect that adjustment. We would then have the line of collimation out of parallelism. A test for this is found in a combination of the second and third adjustments as described hereafter.

shall be on one vertical plane. The former cannot be performed while the latter is out, nor can the latter while the first is greatly in error. Means of making the amount of side motion equal on each side would allow the side adjustment first, but in absence of this the two must be made together, as it were, until approximately correct, when the error of other will not materially affect side adjustment.

The **method** employed is to bring the level by reversals parallel to Y bearings, and in vertical plane by revolving a small arc on either side.

To **perform** it, clamp instrument so telescope will be over one set of screws. Bring bubble in centre by levelling screws, then reverse telescope and level end for end. The amount the bubble moves is double error, one half of which is to be corrected by levelling screws and one half by capstan screws under end of bubble tube. Then revolve the telescope on its bearings 20 or 25 degrees on each side, keeping the motion on each side alike, throwing tube upwards. If bubble runs towards either end the bubble must be drawn over by opposite side screw until on either side the motion is alike, when the first adjustment must be again tested and the two gone over alternately.*

3.—OF THE BAR OR Y's.

The **object** of this is to bring the line of collimation and of level at right angles to vertical axis. It also serves as a test upon the first and second adjustments, determining the equality in size of collars by which these adjustments are made.

The **method** is by comparing position of bubble in reversals upon vertical centre.

To **perform** it, level the instrument over opposite screws and reverse on centre. The amount bubble moves is double error, one half to be corrected by the nuts at end of bar, other by levelling screws. After this is adjusted over the four levelling screws that the bubble remain in centre in all positions, *reverse the telescope on Y's*, as in second adjustment, and then reverse on vertical centre. If adjustment does not remain, the collars in telescope are of different size, and adjustment No. 2 is not perfect. The only remedy is to have collars ground down to same size.

Adjustments No. 1 and 2 affect the correctness of instrument. No. 3, however, does not; it is a convenience as saving the constant levelling when it is not in adjustment; but, independent of its being made in order to test the combined effects of No. 1 and 2, the accuracy of instrument is not affected by it.

---

* When the side adjustment is correct the telescope can be thrown sideways without altering the position of bubble. Should it travel towards the same end on either side the adjustment will not correct it,—the tube is conical in place of being cylindrical. It is not necessary the level should be thrown much sideways, only as much as it is likely to be accidentally thrown out of line in reversing telescope end for end.

Burt's Solar Compass.

There are several adjustments of the Solar Compass required of the manufacturer which are necessary to perfection of instrument, but which the Surveyor cannot and is not called upon to perform. The adjustments of completion of instrument are:

1. The Levels.
2. The Silver Plates of Declination Arc.
3. The Zero of Declination Arc.
4. The Zero of Latitude Arc.
5. Coincidence with Meridian of Zero on Plates.

We have followed in this enumeration the order as given by Mr. Burt. It is very nearly the same as now used by us, and is perhaps more familiar to Surveyors.

1.—OF LEVELS.

This is same as described under head of Transit instrument.

2.—OF SILVER PLATES OF DECLINATION ARC.

The **object** of this adjustment is to ensure line of the image as thrown by one lens shall be parallel to that thrown by other. Its necessity arises from the employment of same arc for north and south declinations and consequent use of two lenses.

The **method** consists in bringing the silver plates in such position that the image of sun will fall between the equatorial lines when the declination arm is reversed on upper and lower edges, by which each line of lenses is brought parallel to sides of arm and consequently parallel to each other.

The adjustment requires practice for proficiency, but is exceedingly important and its frequent examination should not be neglected. Upon it depends the accuracy of declination zero and of all declination readings.

To **perform** adjustment unscrew declination arm and attach in its place the adjuster. Bring instrument approximately to its place as if to make observation, and placing the declination arm on the adjuster bring sun's image to fall between the lines of silver plates, then reverse the declination arm so as to bring upper edge below, carefully, so as not to move any other part of instrument. If this plate is in adjustment the sun's image will fall between lines as before, if not in adjustment it will fall a distance away equal to double the error, and silver plates must be

moved half way. For this purpose the holes in silver plate are large, to admit of motion when the small screws are loosened. When one silver plate is corrected the other is to be likewise adjusted. When both are adjusted a reversal from end to end will test the parallelism of blocks which hold the lenses.

3.—OF ZERO OF DECLINATION ARC.

The **object** of adjustment is to bring the declination arm, when at zero, to a right angle with the polar axis.

The **method** consists simply in raising or lowering the declination arm until it is in such position that the image of sun strikes upon the lines of silver plates when reversed on polar axis.

To **perform** it, set zeros of declination arm and arc together, and by means of level screws of instrument, or by motion of plates, bring sun's image between lines of silver plate; then reverse arc on polar axis. If zero is correct the image will fall upon the other silver plate, if not, bring the image to do so by means of tangent screw and the reading will be double error.

The vernier can be shifted to read correct by loosening the screws which fasten it.

4.—ZERO OF LATITUDE ARC.

The most imperfect part of the Solar, as far as adjustment and corrections are concerned, is the latitude arc. From construction of instrument and the manner in which it becomes necessary to attach the arc, it is impossible to test either whether the arc is truly centered to the axis running through centres on hour circle, or whether the zero starts from correct point. Fortunately neither of these affect the correctness of the work on surveying to any extent. In all work the latitude, *as given by instrument*, should invariably be used; all parts will then be in proper position and no error be to lines run. It may happen that in long distances of northing or southing the difference of latitude as given by Solar may vary from correct differences deduced from measurement, and yet the instrument give in all cases proper lines when latitude is kept tested. The error arises from eccentricity, and as there is no known corrective the Surveyor should be extremely careful to test latitude at every 5 or 10 degrees of difference.

The **method** consists first, in observations north and south of the Equator, or one observation on Sun and another on North Star. In one case the result is given too high and the other too low by the amount of error, so that the mean of the two is correct. The correction is necessary in determining the exact latitude of the place, but not so important in use of instrument.

Another method where latitude is known, and one which is generally used, is observing the sun at noon and bringing the latitude arc so that

the sun's image shall fall between equatorial lines when at its highest point or noon.

To **perform** adjustment by first method is simply making the two observations, one on the sun and other on star.

To **perform** by second method, the instrument should be set up about ten minutes before apparent noon, with declination and refraction set off on declination arc, and the latitude arc raised or lowered by tangent screw, until by motion of the horizontal plate and declination arc the sun is brought between the equatorial lines. As sun approaches noon it will be found necessary to raise latitude arc, as well as move the horizontal plates and declination arc, in order to keep sun's image between lines,—and will be highest at noon. When at highest point the latitude should be read, and if it differs from known latitude the vernier should be shifted by loosening screws.

Another method employed to find zero of latitude arc is to make observation in morning with latitude as given by instrument, and place meridian mark; then with same reading of latitude make observation in afternoon. The meridian for this purpose is half way between these two, and latitude arc should be changed so as to bring the instrument to read on this meridian. In place of meridian the bearing of any object may be taken.

This is a speedy method of testing and getting latitude. It is not an effectual test, for it partakes of any error existing in the polar axis and the axis of latitude arc, not being at right angles, but has the advantage of dividing the errors; and as finding the latitude by regular method of observation at noon may be interfered with by a slight cloud at the moment, it is frequently used. Whenever possible, however, the noon method should be used.

5.—COINCIDENCE OF MERIDIAN WITH ZERO OF PLATES.

The **object** is to ascertain whether the sights (or telescope) and the vernier have been placed properly with each other.

The **method** consists in bringing the sights (or telescope) on line at right angles with polar axis when same is made horizontal, and setting the verniers to zero; or the reverse, of setting the verniers to zero and bring the sights (or telescope) at right angles to polar axis.

To **perform** it, release the latitude arc and raise it until the polar axis is horizontal; place equatorial sights on the lens blocks; bring the declination arc to zero, and sight on distant object; then bring sights (or telescope) on same object, and the vernier of main plates should read zero.

The correction is made by either, by moving verniers of plates to zero, or by shifting sights so they shall bear upon same object as equatorial sights when the zero of plates coincide.

Another and simpler method, where a meridian line is established or can be obtained is, after making certain previous adjustments correct, to

compare the line as given by a compass and shift vernier or sights over to suit the same.

Besides the above, Burt gives an adjustment, which he calls the fourth, to bring polar axis at a right angle with the axis of latitude arc. We are satisfied that the Surveyor cannot make this adjustment, and believe Burt's method to be liable to an intermediate mechanical error, which the adjustment does not provide for, and which may be the cause of some inaccuracy in results. We have provided within the few years past a severe test for this, and believe our instruments as now constructed to be more efficient on this account.

The object of the adjustment is bring the polar axis at right angles to axis of latitude arc, so that the readings given on each side of meridian, or on the morning and afternoon, may be alike. The failure of solar most generally occurs upon this point, and the solar is the nearer perfect as it determines the lines of the morning and afternoon alike.

Meridian Attachment
for
Transit Instruments.

THIS ACCOUNT OF THE SOLAR COMPASS, AND THE MERIDIAN ATTACHMENT FOR TRANSIT INSTRUMENTS, WAS WRITTEN FOR YOUNG & SONS, BY BENJ. H. SMITH.

Although the Solar Compass has been in constant use since 1835, and, with its modern improvements has become one of the most useful instruments known to the surveying profession; yet, it is a remarkable fact, that its existence has been almost entirely ignored by the authors of all the modern text-books on surveying commonly used in schools and colleges.

As a consequence, the young surveyor who soon finds the use of the solar apparatus attached to his transit indispensable in his practice, is obliged to resort to his own ingenuity to master the principles upon which the instrument is based, or depend upon the imperfect and often incorrect account to be found in the catalogue of the instrument maker he may happen to have on hand.

To attempt to adjust and use any instrument without thoroughly understanding its principles, can only result in unreliable work, which fact has been notably demonstrated in the use, or rather abuse of the Solar Transit.

It is the design of this paper to supply a clear and concise account of the instrument and its modifications, for the use of surveyors, and especially of those who may not be familiar with the astronomical problems involved in its construction, a brief explanation of which will first be given.

The Diurnal Motion.

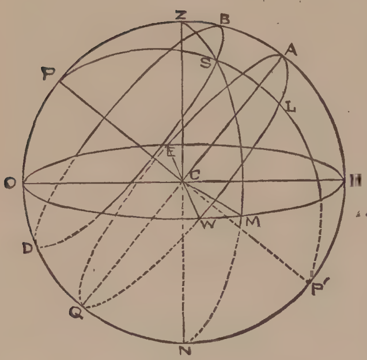


Fig. 1.

For our purpose, the earth, so infinitely small in comparison with celestial magnitudes, may be supposed to be a fixed point C in space around which revolves the celestial sphere O N H Z, Fig. 1, in which Z represents the ZENITH and N the NADIR of the observer; P C P′ the POLAR AXIS, about which the diurnal motion is apparently performed; O E H W the celestial HORIZON whose poles are Z and N, and A E Q W the celestial EQUATOR whose poles are P and P′. All circles passing through Z and N are called VERTICALS, and those through P and P′ are MERIDIANS or hour circles, the one passing also through Z being the meridian of the place, or simply THE MERIDIAN.

All the circles mentioned are GREAT circles, that is, circles whose planes pass through C the center of the sphere. The circle B S D, described by the star at S in its diurnal motion, is a LESS circle. The distance from P or P′ to any object on a meridian is called its POLAR DISTANCE, and the remainder of the quadrant measured from the equator is called its DECLINATION. The distance from the zenith to any object on a vertical is its ZENITH DISTANCE, and the remainder of the quadrant to the horizon is called its ALTITUDE. Thus, P S is the polar distance, L S the declination, Z S the zenith distance, and M S the altitude of the star S. O and H are the north and south points, and E and W the east and west points of the horizon. The direction of an object, whether terrestrial or celestial, with reference to the plane of the meridian, is called its AZIMUTH or BEARING. O M or the angle P Z S is the azimuth of any object.

S or M, in the vertical P S M reckoned from the north point. The angle Z P S, which the circle P S P′ makes with the meridian, is called the HOUR ANGLE of the star S.

Careful observations of the motions of the stars, if continued for a sufficient period, will show that although their relative positions, and, therefore, polar distances and declinations, remain unchanged, they all seem to revolve with a uniform motion from east to west as though attached to the internal surface of a vast hollow sphere, having the observer in its centre and turning round the axis P C P′, inclined to the horizon at an angle equal to the latitude of the place. This apparent rotation of the heavens is called the DIURNAL MOTION.

All bearings in land surveys being referred to the line H O, the correct determination of the direction of that line for any particular place is of utmost importance to the engineer and surveyor. The pole star whose polar distance is less than one degree and a half is a very convenient object for this purpose; and, also, at the same time, for determining the arc P O or latitude of the place.

The Engineer's Transit being an altitude and azimuth instrument, can be used to take equal altitudes of the sun or of a star from which the meridian is readily determined, or the latitude and declination being known, the azimuth and hour angle may be computed from a single altitude of the sun or a star as follows: In the spherical triangle P Z S are given the three sides, P Z the complement of the latitude, P S the polar distance or complement of the declination, and Z S the zenith distance or complement of the altitude, whence P Z S (= O C M) the azimuth, Z P S the hour angle, and Z S P the parallactic angle may be calculated.

These methods all result in a sure determination of the meridian, but the time involved in taking and reducing the observations is not always available to the engineer. Hence, the great value of a Meridian Attachment which will mechanically and instantly solve the problem above mentioned from a single observation of the sun, the apparent motion of which will be next considered.

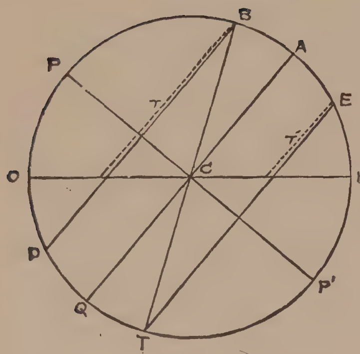


FIG. 2.

If observations be taken at C, Fig. 2, during a whole year, it will be found that independently of the diurnal motion which the sun has in common with the stars, it has also a motion in declination causing it to appear to describe annually the great circle B T called the ecliptic, the plane of which forms an angle of about 23° 28′ with the celestial equator A Q. The sun will appear to describe the circle B D at its greatest north declination on the 21st of June, and the circle E T at its greatest south declination on the 22d of December. Its declination will be zero when crossing the equator on the 21st of March and 23d of September, respectively.

The Meridian Attachment is simply an instrument made to imitate, on a small scale, the motion of the celestial vault as above described, consisting of a Solar Telescope revolving about its polar axis, which corresponds with P C P′, in such a manner, that the line of collimation will follow the sun or any star in its apparent diurnal motion round the earth. Conversely when the transit is turned on its vertical axis to a position where the Solar Telescope when revolved on its axis will follow the sun or star, its axis must be in the line P C P′, and, therefore, in the meridian of the place. This principle was first utilized, but for a different purpose, in the construction of the Universal Ring Dial, more than a century ago, and a description of that simple instrument, will best illustrate the subject for the reason, that all the many forms of solar attachments are constructed upon the same principles, and may be said to be mere modifications of the Ring Dial.

The Ring Dial.

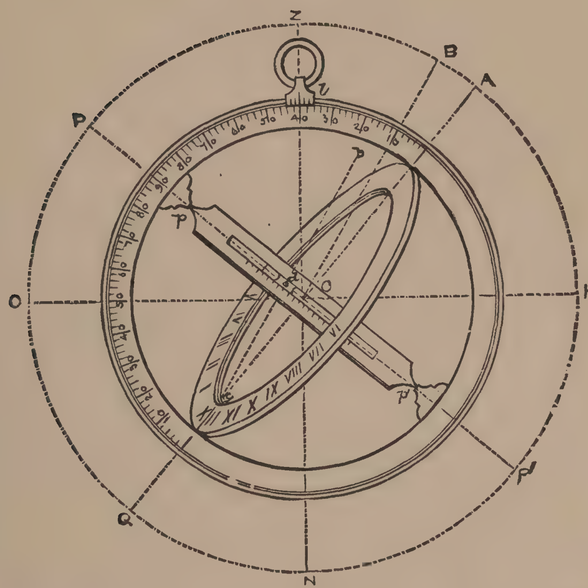


FIG. 3.—Ring Dial. H O, Horizon; P P, Polar Axis; A Q, Equator; A C Z = P C O, Latitude; A *c* *b* = A *c* B, North Declination.

The Ring Dial, Fig. 3, consisted of two rings of brass or other metal, which being turned at right angles with each other, corresponded with the equatorial and meridian circles A E Q W and O Z H N, Fig. 1, and a plate turning on pivots at *p* and *p′* represented the polar axis P C P′. In an opening in this plate moved a brass block *d* through a small aperture in which the sun's image was projected on a line engraved on the inner edge of the equatorial circle. The block *d* could be set to any required declination A C B, by means of graduations along the opening in which it moved. The meridian circle was utilized as a latitude arc. The dial was suspended from a ring attached to the vernier *l* which was set to the latitude of the place, A Z

(= P O). The axis of the instrument then corresponded with the line Z N and was revolved slowly thereon, until the sun's image crossed the equatorial line, the hour being indicated by graduations upon the lower half of the equatorial circle.

With the instrument firmly fixed in this position, the sun's image would follow the equatorial line, and, hence, its axis of motion would correspond with $p p'$, which would then coincide with the polar axis P P′, and, hence, with the direction of the meridian.

The Ring Dial, if properly mounted, would, therefore, answer all the purposes of a Solar Compass in determining the meridian as well as the time of day.

Burt's Solar Compass.

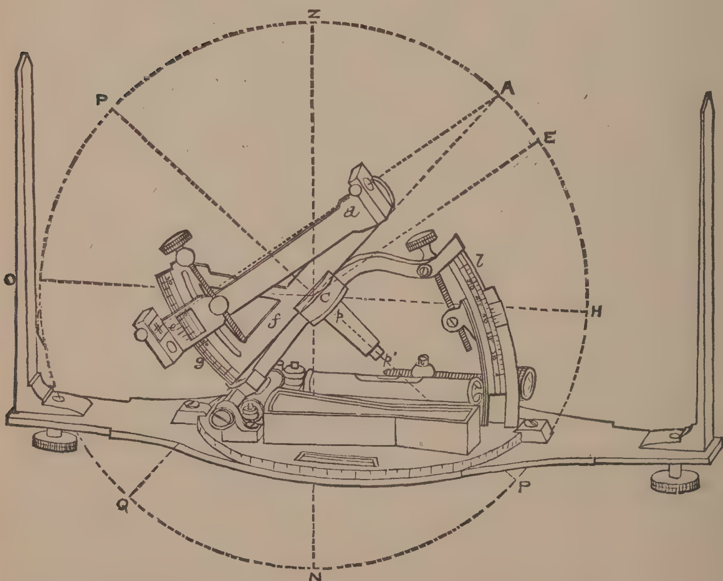


FIG. 4.—Burt's Solar Compass. H O, Horizon; P P, Polar Axis; A Q, Equator; A C Z = P C O, Latitude; C A e = A C E, South Declination.

The first practical application of these principles to the art of surveying, was made by William A. Burt, of Michigan, in his invention of the Solar Compass, the prominent features of which are represented in Fig. 4. The bar *f* revolves in the plane of the equator A Q about the polar axis $p\,p'$, carrying the declination arc *g* and bar *d e*. The sun's image is brought to a focus at the intersection of lines engraved on a silver plate at *e* by means of a lens in the opposite end of the bar. To find the meridian, the latitude P C O is set off on the latitude arc *l*, and the declination A C E on the declination arc *g*. The Compass is then revolved about its vertical axis Z N, and the Solar apparatus about its polar axis until the image of the sun is brought accurately within the lines at *e*, when the axis $p\,p'$ must, necessarily, correspond with the plane of the meridian.

This invention was originally designed, and was admirably adapted for use in connection with the open sight compass for work on the public land surveys, but when the Engineer's Transit came into more general use, and a higher order of land surveying was demanded, various attempts were made to attach the Burt apparatus to the Transit, but never with satisfactory results. It has been mounted over the needle box, under the main plate, on the end of the axis, on top, and even on the object end of the Telescope, but in every case at the expense of the usefulness of the Transit.

The Meridian Attachment.

With a view of meeting these objections, the writer, a few years ago, designed a form of Meridian Attachment, especially for use in connection with the Engineer's Transit, which has since been manufactured by Messrs. Young & Sons, to whom belongs the credit due to skillful workmanship and good judgment in the arrangement of the details of construction. After six years' trial in the field, it is found that the following advantages over the old form have been secured:

(a) Compactness of form, especially adapting it for attachment to the Engineer's Transit. The instrument being complete in itself, the Transit Telescope and vertical arc are not

required to do double duty. The view of the needle box and verniers is unobstructed.

(b) The sun being observed through a telescope, its image can be brought sharp and clear between the equatorial wires with greater exactness than can be attained by the old plan of focussing upon a silver plate; and, hence, the meridional result is more accurate.

(c) The polar axis, which from the preceding remarks will be recognized as the vital part of a Solar Attachment, is longer than in any other form.

(d) The sun's image can be clearly defined in hazy weather when the old forms cannot be used at all.

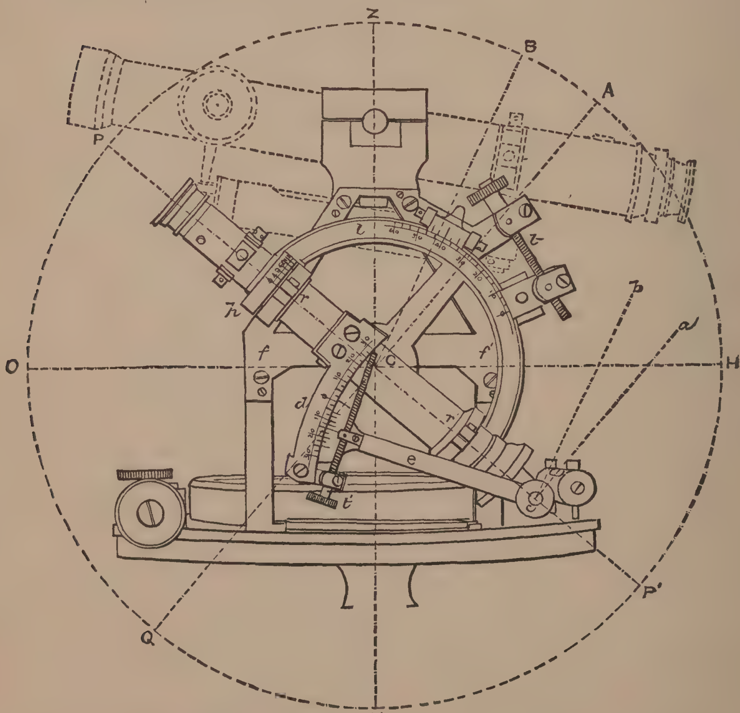


FIG. 5.—Smith's Meridian Attachment. H O, Horizon; P P, Polar Axis; A Q, Equator· A C Z = P C O, Latitude; $a\,c\,b$ = A C B, North Declination.

The Meridian Attachment is represented in Fig. 5; C is the Solar Telescope revolving in collars *r* and *r′*, whose line of collimation and axis of revolution coincide with the polar axis P P′. The declination arc *d* is fixed to the side of the Telescope, the vernier being attached to the arm *e* which turns on its axis a reflector at *c* in front of the object-glass of the Telescope. The collars in which the Telescope revolves are firmly attached to the latitude arc *l*, having a horizontal axis, the whole being mounted on the frame *f f′* which is attached to the standards of the Transit. Tangent screws *t* and *t′* give slow motions to the declination arm and latitude arc.

The arm *e* is so adjusted that the declination vernier reads zero when the plane of the reflector makes an angle of 45° with the axis of the Telescope, in which position the line of collimation is reflected at right angles, and is caused to coincide with the line *a c* parallel with A C. Hence, if the Telescope be revolved on its polar axis, the line of collimation will describe the celestial equator A E Q W, Fig. 1. In like manner, by setting off on the declination arc any given declination north or south, as A C B or A C E, the image of any celestial object traversing the circles B D or E T, Fig. 2, may be kept in the center of the field of view from rising to setting, by simply revolving the Telescope. The hour arc is attached to the Telescope at *h*, revolving at right angles with the polar axis, and, hence, in the plane of the equator.

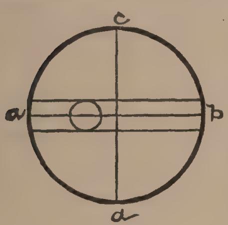


Fig. 6.

The appearance of the sun in the field of view is represented in Fig. 6. The three equatorial wires *a b* correspond with the line of the celestial equator and circles parallel therewith, while the hour wire *c d* corresponds with the hour circle or meridian towards which it may be directed.

The meridian is found in precisely the same manner as with the Ring Dial and Burt Solar Compass. Having set off the latitude and declination, and the hour circle to the approximate time, the sun can generally be brought into

the field of view by simply revolving the Transit on its vertical axis. The Transit then being clamped, the sun may be brought accurately between the equatorial wires with the tangent screws, at which time the Solar Telescope and also the Transit Telescope parallel to it, will be in the plane of the meridian.

The same letters and lines have been used in the foregoing figures for purposes of comparison, and to show the reader how the three instruments described are based upon the same principles.

Latitude.

It will be readily understood from the above explanations, that the Meridian Attachment in common with all forms of solar devices for determining the meridian, depends for accuracy of results upon the indispensable condition that the polar axis of the instrument must coincide with the line P P′, Fig. 2, at some time during a revolution of the Transit on its vertical axis. Hence, the most important requirement is a correct determination of the angle P C O or the latitude of the place of observation. Whether ascertained from accurate maps or charts, or from direct observations by some of the well-known methods, the latitude should be known within one minute to ensure a correct meridional result.

Declination and Refraction.

The apparent declinations of the sun at Greenwich mean noon, and the hourly differences may be found in the Nautical Almanac. To calculate the declinations, it requires an approximate knowledge of the longitude of the place, which can be determined from any good map with sufficient accuracy.

The effect of refraction is to apparently increase the altitude of celestial objects. In Fig. 2, if B D and E T represent two diurnal circles described by the sun, one with north and the other with south declination, the dotted lines r and r' will represent the apparent path of the sun as affected by refraction. It will be seen that the effect on the declination will be to apparently increase it when north, and decrease it when south. The cor-

rection is, therefore, made by adding the correction for refraction to north, and subtracting it from south declinations.

The tables of refractions being calculated for verticals, cannot be applied to declinations, which are measured on meridians, without special computations. Hence, the necessity of the table of *refractions in declinations*, prepared by Hon. Cortez Fessenden, and published for use with the Solar Transit by Young & Sons. The table is calculated for all hours of the day, and for any latitude from 30° to 55°.

The method of calculating the declinations for a day's work can be best illustrated by an example:

Time, November 1, 1886. Station, Denver, Colorado.

Latitude 39° 45′ N. Longitude 105° 00′ W.

From the Nautical Almanac,

Declination, S. 14° 30′ 19.4″. Difference for 1 hour — 48.0″, the — sign indicating that south declination is increasing.

From table of refractions in declination for nearest latitude 40° and declination — 15°, the corrections are for noon, 1′ 21″, 1 hour 1′ 25″, 2 hours 1′ 35″, 3 hours 2′ 01″, 4 hours 3′ 18″.

Reducing the longitude 105° to time by dividing by 15 (15° of arc = 1 hour) gives 7 hours; and, therefore, Greenwich noon corresponds with 5 A. M., at Denver. The declination being south, the corrections for refraction are subtracted, hence, the following results:

Time.	Declination.		Refraction.		Corrected Declination.
5 A. M.	14° 30′ 19.4″				
+ 3 × 48″ =	2 24				
8 A. M.	14 32 43.4	—	3′ 18″	=	14° 29′ 25.4″
+ 48″					
9 A. M.	14 33 31.4	—	2 01	=	14 31 30.4
10 A. M.	14 34 19.4	—	1 35	=	14 32 44.4
11 A. M.	14 35 07.4	—	1 25	=	14 33 42.4
Noon,	14 35 55.4	—	1 21	=	14 34 34.4
1 P. M.	14 36 43.4	—	1 25	=	14 35 18.4
2 P. M.	14 37 31.4	—	1 35	=	14 35 56.4
3 P. M.	14 38 19.4	—	2 01	=	14 36 18.4
4 P. M.	14 39 07.4	—	3 18	=	14 35 49.4

As the declination arc is only graduated to minutes, the results may be transferred to the field book for reference, as follows:

November 1. 1886.

Noon, 14° 34′ 34.4″.

8 A. M., 14° 29′	1 P. M., 14° 35′
9 A. M., 14 31	2 P. M., 14 36
10 A. M., 14 33	3 P. M., 14 36
11 A. M., 14 34	4 P. M., 14 36

Adjustments.

From the foregoing synopsis, it will be apparent that the following conditions must be established in the construction of a theoretically perfect Meridian Attachment:

(a) The Transit to which it is attached should be in perfect adjustment.

(b) When the optical axis of the Solar Telescope is horizontal, the latitude vernier should read zero.

(c) The axis of the reflector should be at right angles with the optical axis of the Telescope, and when its plane is at 45° therewith, the declination vernier should read zero.

(d) The axis of the latitude arc should be horizontal and at right angles with the optical axis of the Transit and Solar Telescopes.

(e) The equatorial wires must coincide with the line of the celestial equator, and the hour wire be at right angles therewith.

It is supposed that the reader is familiar with all the adjustments of the Transit, but it may be worth while to remind him that good solar work cannot be effected unless his Transit is a first-class one, and in perfect adjustment.

The adjustments of the Meridian Attachment are as follows:

The Latitude Vernier. Set the latitude arc at zero, clamp it, and place the striding level upon the Telescope. Bring the bubble to the centre by turning the tangent screw *t*. Then reverse the level, and if the bubble settles in the same position as before, we may conclude that the axis is horizontal; but, if

the bubble moves from its former position, turn the screw so as to move the bubble over half this distance, the other half to be ascribed to error in the level itself. If, when the level is reversed, the bubble occupies a similar position in the opposite direction, the adjustment is complete. The vernier will now indicate the index error, which may be corrected by shifting the vernier by means of the adjusting screws for that purpose.

The Declination Arc. Having set off the latitude, take an observation of the sun on the meridian, and bring its image accurately between the equatorial wires by means of the tangent screw t'. The difference between the observed and calculated declinations corrected for refraction will be the index error, which may be corrected by loosening the three small screws on top of the arc, and moving the arc to the correct reading.

The Plane of the Latitude Arc. The axis of the latitude arc and that of the reflector should be placed by the maker at right angles with the optical axis of the Solar Telescope, and are not liable to derangement. The vertical planes of the latitude arc and the Solar and Transit Telescopes should also be made parallel; but as this condition is sometimes disturbed in detaching and attaching the apparatus to the standards, the following is the adjustment:

Having completed the adjustments above described, take a solar observation at say, 9 A. M., and note the error east or west of the meridian as indicated by the Transit Telescope directed south. Bring Transit Telescope to the meridian with the tangent screws. This will cause the sun's image to leave the equatorial wires diagonally. Then by means of the small butting screws in the plate ff', move the south end of the plate east, if the error was east, or west, if it was west, until the sun is accurately between the wires. A solar observation at 3 P. M. will verify the adjustment; but, if the morning and afternoon observations cannot be made to agree, then a portion of the error must be ascribed to the plane of the reflector not being truly at right angles with the line of collimation. The adjustment of the reflector should be perfected by the maker, and is not liable to get out of order. THE SURVEYOR IS RECOM-

MENDED, THEREFORE, IN SUCH A CASE TO ALLOW FOR THE MERIDIAN ERROR IF SMALL, BUT IF LARGE, TO RETURN THE INSTRUMENT TO THE MANUFACTURER FOR RE-ADJUSTMENT.

The Equatorial and Hour Wires. If the sun in traversing the field of view should appear to depart from the equatorial wires, the correction can be made by loosening the screws and rotating the diaphram carrying the cross wires, until the sun appears to follow the equatorial wires accurately.

All these adjustments are made by the manufacturer, and are not liable with careful usage, to become deranged. They should, however, always be verified before beginning any important work.

FROM TRANSACTIONS OF

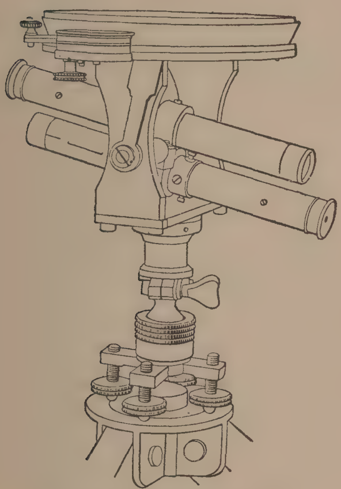
THE AMERICAN INSTITUTE OF MINING ENGINEERS.

The Evolution of Mine-Surveying Instruments.

BY DUNBAR D. SCOTT, HOUGHTON, MICH.

ALFRED C. YOUNG* (communication to the Secretary): Before the appearance of Mr. Scott's paper in these *Transactions* we were not specially interested in the investigation which he has started; but at his request we have endeavored to collect from musty records and the recollection of our old friends a brief chronicle of the progress made by this house.

FIG. 92



Bartelot's Mining Compass

As 3000 instruments were manufactured by us before any descriptive record was kept, and 2000 more before the record contained more than a statement whether the instrument was a transit or a level, and sometimes its size, we approach the task with timidity, trusting that the reader will bear the difficulties in mind, particularly as the writer's predecessors, from whom, no doubt, the information desired could have been obtained, have passed away.

Instruments for surveying were manufactured by David Rittenhouse, of Philadelphia, as early as 1760; but it was not until late in the first quarter of this century that there was any American market for an instrument outside of the ordinary surveyor's compass. With the advent of canals and railroads, and the more extensive development of the Pennsylvania coal-fields, arose a demand for surveying-instruments to meet problems in engineering beyond the limited field of the compass.

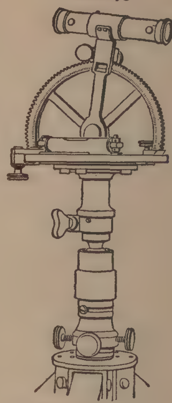
On May 1, 1820, in which year the practical mining of anthracite coal in Pennsylvania began, William J. Young, who had served his apprenticeship with one Thomas Whitney, started in business on Dock Street, in Philadelphia. Recognizing the fact that compasses, or "circumferentors," as they were commonly called, were not equal to the demands made upon them, and that the English theodolites had too many parts liable to injury, were cumbersome and ill-adapted to transportation, Mr. Young commenced to plan an

*Conducting the establishment of Young & Sons, Philadelphia, Pa.

instrument that would permit horizontal angles to be taken independently of the needle, and allow "back-sights" to be obtained without reversing the telescope in its bearings.

In 1831 he introduced the first "American engineer's transit." From that time to the present *all* improvements have been merely in the perfecting of details and the addition of attachments to meet special requirements—so well were the fundamental principles thought out by the inventor, even to such minor features as the placing of the verniers at one side of the standards, so as not to risk disturbance of the instrument while the readings were taken.

FIG. 93

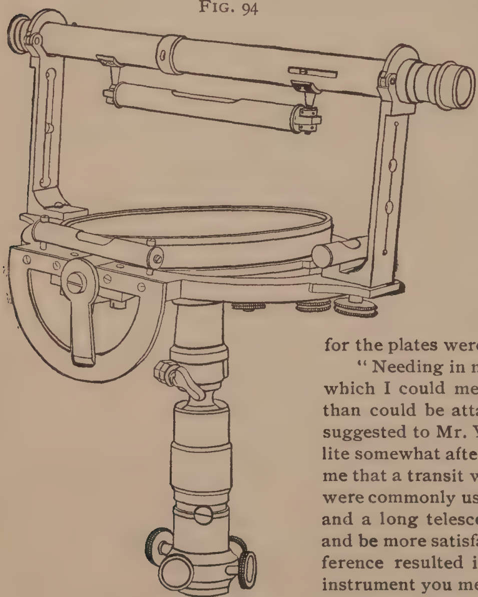


Mulloney's Mining Dial

In July, 1858, he patented the "shifting-tripod-head." By simply loosening the leveling-screws, the transit can be shifted a short distance in any direction after the instrument has been approximately set up. No improvement has been made in this invention since its introduction.

The first compound "long-center" transit was made for J. Simpson Africa, Esq., President of the Union Trust Company of this city, who, in a letter dated February 1st, 1899, says:

FIG. 94



The Smith-Hedley Dial

"I am reminded that the first long-center transit-instrument mentioned in your books was purchased by me November 11, 1853.

"My engineering records and papers being at my old home (Huntingdon, Pa.), the only information I can give now is from recollection. Through my instructor in practical engineering, Mr. Samuel W. Mifflin, I made the acquaintance of Mr. William J. Young, the founder of your house. One of my duties was to test, in actual surveys, transits that he had made for a railroad then in progress of construction. All these had short reversible telescopes, and verniers for the plates were *within* the compass-box.

"Needing in my own business an instrument with which I could measure angles with greater precision than could be attained by those mentioned above, I suggested to Mr. Young to construct for me a theodolite somewhat after the English model. He convinced me that a transit with a long center, wider plates than were commonly used, verniers outside the needle-box, and a long telescope, would meet my requirements, and be more satisfactory than a theodolite. This conference resulted in my giving him an order for the instrument you mentioned.

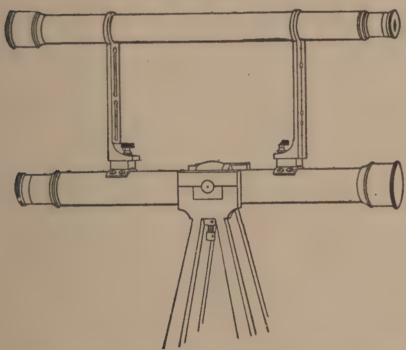
"I used it with great pleasure and satisfaction for many years in general engineering work, and especi-

ally in the laying-out of towns, and in defining disputed boundaries, where the greatest attainable accuracy was desired. Many years later I had another transit made at your establishment, built on the same general plan with the then modern improvements added. This instrument took the place of the one made in 1853, and is now in use by one of my sons."

As to the dates of the introduction of the various forms of mining attachments to engineers' transits, and the names of those who suggested these improvements, our early records supply but meager information. Fortunately, however, some of the instruments are still in existence, from which photographs have been obtained, leaving in doubt only to whom the honors may belong. The following list comprises mining instruments made by this house at various times, and not hitherto mentioned in this discussion.

Fig. 92 (our shop No. 3366) represents an instrument made in April, 1855, for a Dr. Bartelot, who seems to have lived in the anthracite coal regions of Pennsylvania. The instrument was intended only for magnetic surveys, so that the compass box was placed conspicuously above, where observations of the needle would be least obstructed. The compass was provided with what was then known as a "Nonius-plate"—a simple marginal indicator that marked off the degrees, and the larger sub-divisions thereof, to be used in allowing for variation. I suppose Pedro Nunez, the Portuguese mathematician, who lived in the first half of the sixteenth century, was the first to use this device, but Rittenhouse is said to have been the first to use the vernier for this purpose. The complete revolution of a telescope in a design of this peculiar kind was impossible; and the method resorted to of using duplex telescopes for forward and back-sighting, makes this model, so far as we know, unique among mine-surveying instruments. The only other type at all similar is Mr. Hoskold's which he was perfecting some two years later; but the methods employed in each case will scarcely permit a comparison. The duplex telescopes revolved about 20° from the horizon each way, upon a common axis, that could be adjusted for horizontality by means of the capstan-head screws shown in the figure just below the base of the standards; but their adjustment for parallelism could only be secured by the maker. The instrument was leveled by the ball and socket base, the four leveling-screws and the box-bubble at the side of the compass-box.

FIG. 95

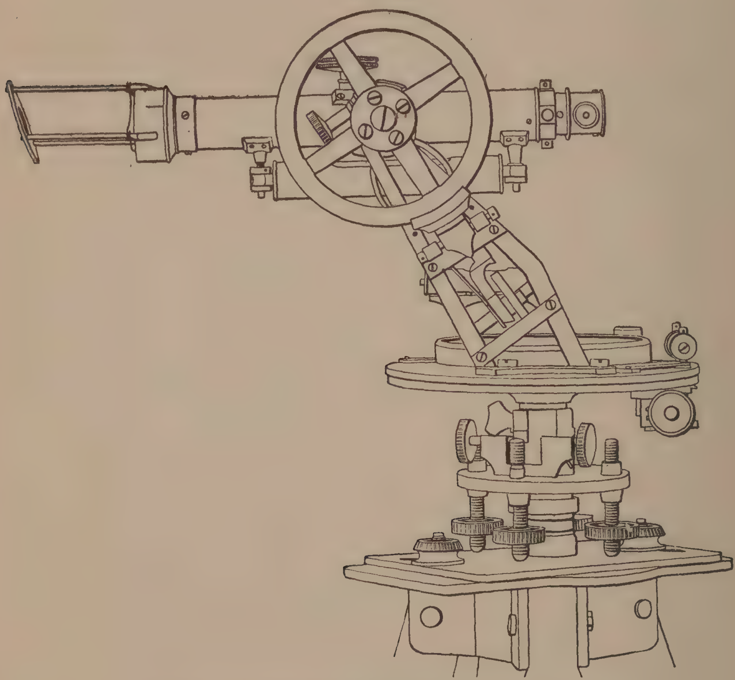


Petherick's Mine Transit with the First of Top-Auxiliary Telescopes.

Fig. 93 (our shop No. 3448) represents a mining instrument made in October, 1855, for J. F. Mulloney. It is decidedly of English parentage,

possessing the same rack-movement shown in Fig 16, and an arch much as it appears in Fig. 15. The horizontal plates were maneuvered by the same kind of rack-work. But the most remarkable feature is the substitution of "Locke's sights" for the telescope. These sights are practically what are known to-day as Locke's hand-level, invented by Prof. John Locke, M.D., of Cincinnati, in 1850. I suppose Mr. Mulloney wished to use the sights for leveling purposes, and, as they did not permit accurate centering, he very wisely demanded that the arch be graduated and read by a simple index to only ½°. The base of this instrument is very tall, slender

FIG. 96



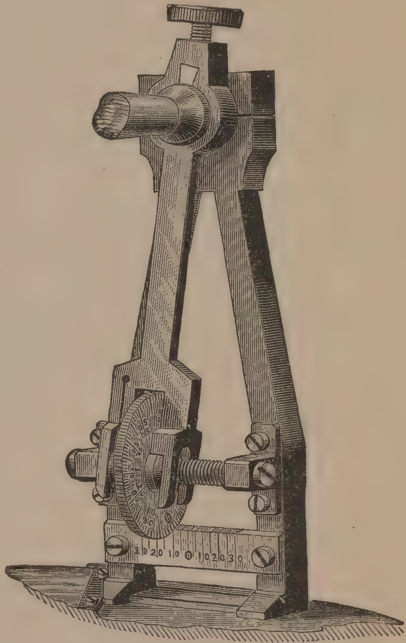
McNair's Original Inclined-Standard Mine Transit.

and really an ill-proportioned type, though it was very common in those days. From the ball there extended down through the barrel a square shank, upon the faces of which worked the opposing screws shown just above the tripod head. After clamping the ball and socket tightly, the instrument could be brought to a more perfect level by use of these screws. Two extra tripods with sockets for holding candles, as is common in Cornwall to-day, were furnished with this instrument.

Fig. 94 (our shop No. 3545) represents a modification of the Hedley dial, made in October, 1855, for Thomas Smith, of Luzerne county, Pa., and

bears the distinction, we believe, of being the first Hedley dial ever provided with a telescope, Mr. Stanley's instrument not being made until 1874. The Smith-Hedley dial had within the compass-box a horizontal plate, graduated to read minutes, that was governed in its movements also by rack-work. The rocking limb was 10 in. long and provided with a side arc upon which grades as great as 70° could be observed before the limb came in contact with the base. In this particular this style of base or support is superior to the Hoffman-Harden tripod-head used by Mr. Stanley, until he remodeled the rocking limb so as to permit vertical sights. However, these instruments are out of date now in this country, though there was a time when they were widely used in railroad construction. It is from this instrument that compasses designed to give horizontal angles independently of the magnetic needle received, and still bear, the name "railroad compasses."

FIG. 97



Young's Gradienter

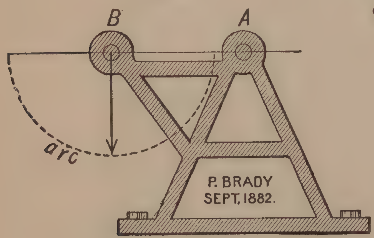
It was but a step in the line of progress to mount the telescope in Y's, as shown in Fig. 95, and attach it to the instrument shown by Mr. Scott in Fig. 34. We believe that this was the first American top-auxiliary telescope, and that the opinion ascribed to Mr. ——— is not well founded. We are not positive as to the exact date of the introduction, but we present in Fig. 95 what was doubtless the pioneer instrument of the top-auxiliary type, and as far as we have been able to determine, it was made for Mr. Wm. Petherick, Superintendent of the Copper Falls Mines, Mich., 1855-60, apparently from drawings furnished by him.

As first made, the auxiliary telescope was clamped on the main telescope about the same as compass-sights, but would never clamp in line with the main telescope. Then the uprights were attached permanently to the transit-telescope, and the auxiliary only was made detachable, as well as reversible, "end for end" (somewhat as shown in Fig. 94); but in this form the uprights would get bent in the mines, and render the attachment useless. A hinged upright was then tried, similar to the folding compass-sight but the hinge pin would wear, and the uprights rattle.

The writer's plan, introduced in 1891, is to mount the uprights upon a base-plate, and attach it to the main telescope by "Y" bearings.

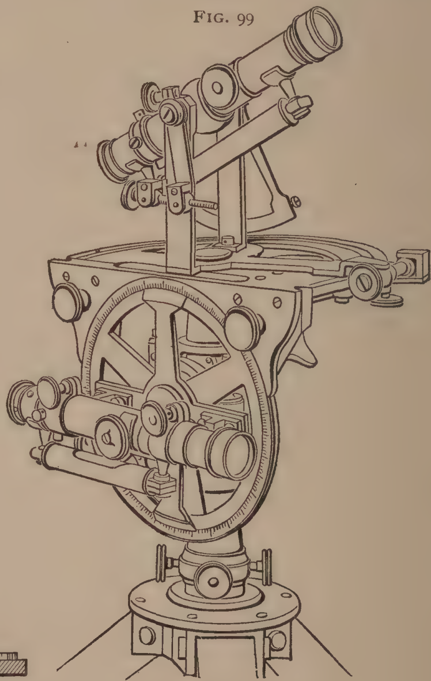
When Mr. Scott assumes that the inclined-standard mining-transit came down through Seibert's solar, he is not entirely correct. As a matter of fact, the first inclined standards made by this house were made in July, 1854, for Alexander Roberts, of Hamburg, Pa. In the next year we made one of the same kind with long center, double verniers and telescope-level, but no vertical arc, for the Philadelphia, Wilmington & Baltimore R. R., but we have no photograph or further description of these instruments. From this time on, no others of this pattern seem to have been made by us until that made in 1875 for Thomas S. McNair, then mining engineer for the Lehigh Valley Coal Company, at Hazelton, Pa. It was at this time that our Mr. Thomas N. Watson, in the course of the argument, suggested the principle of the "hinged-standards" by revolving a draughtsman's triangle on one of its corners. The idea was rejected; but it seems to us now that if unusually large journals had been used and the adjustment had been secured as in the horizontal axis of the telescope, it could have been made to project correct alignments.

FIG. 98



Brady's Proposition

FIG. 99



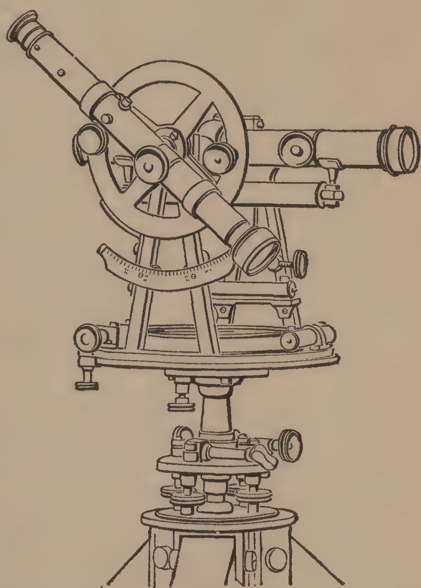
Hulbert's First Instrument

Mr. McNair's instrument is still in use, and is reproduced here, (Fig. 96) from a photograph kindly prepared by that gentleman especially for this discussion. The credit for first having used this type in mining work is possibly due to Mr. McNair; but he modestly refuses to accept it without reserve, observing, "The ancients, you know, are said to have infringed on our inventions." Attached to this instrument will be noticed the style of gradienter introduced by this house in 1872, the first, we believe, to appear in America. It is shown more in detail in Fig. 97. We use it still, for the reason that it is not so exposed as the other style, and is equally easy to read and manipulate.

Of distinctively mining transits, there are probably more of the inclined standard type in use than any other, all objections to its eccentricity and "overhang" melting away wherever it has once been used. It has achieved this recognition without any special recommendation on the part of the makers.

From this time on, the desirability of combining the advantages of McNair's model with those of the concentric type began to occupy the minds of engineers. In 1882, Mr. Peter Brady, then connected with the Glendon Iron Co., Easton, Pa., suggested to the writer the advisability of designing a mining instrument (Fig. 98), substantially what is known to-day as the duplex-bearing mine transit. It was pointed out to him that the structure, with all the necessary appliances, would be so cumbersome as to merit the present well-deserved name of "steam-engine;" that there would be great difficulty in keeping the bearings free from grit and in proper adjustment, and the great liability of the changeable parts to injury; so, upon due consideration, the idea was abandoned.

FIG. 100



Hulbert's Original Side-Telescope Transit

In 1854, Edwin J. Hulbert ordered of us, as he has explained, an instrument (Fig. 99) known then as the "Lake Superior pattern." Figs. 99 and 100 show some features not clearly seen in the illustrations given by Mr. Hulbert. In Fig. 99 the upper plate was semicircular, 8 in. in diameter, reading by a single vernier to minutes. The vernier was in the clamping-arm or alidade of the upper limb, and was also provided with a small tangent-screw. The telescope was provided with a vertical arc, clamp and tangent-screw and loose vernier-arm, as introduced by Alfred Young in 1850. The side-telescope, having a level attached, was mounted on a free vertical circle, 6½ in. in diameter, reading by two verniers to minutes; a clamp and tangent were also provided; all mounted on a compound ball-and-socket with leveling screws. Not many of these instruments were made. While seeming to fulfill particular requirements in the copper regions of Michigan, they were not favorites with the instrument-maker, on account of the peculiar shape of the plates, the contraction and expansion of which were apt to destroy the adjustments; and the absence of the needle was at that time a popular objection on the part of the engineer.

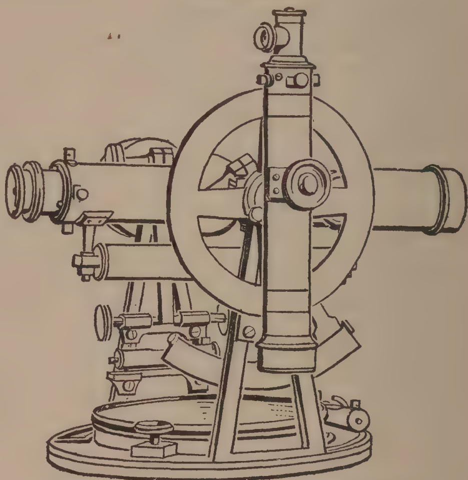
Fig. 100 shows what was probably the first side-auxiliary telescope attached to a mine-transit in America or elsewhere. It was made for Mr.

Hulbert, from designs furnished by him, as he explains, in 1856. A full vertical circle was connected permanently with the axle of the transit telescope. The auxiliary telescope, which alone was detachable, was attached to the vertical circle by means of two milled-head clamp-screws.

Fig. 101 illustrates an improvement in Mr. Hulbert's pattern. The telescope is much shorter and larger in diameter, and is permanently connected with the full vertical circle, which is also made detachable.

Later, several methods were adopted to simplify the attachment of a side-auxiliary, one of which was a perforation of the horizontal axis large enough to permit the insertion of a spindle attached to the telescope The objection to this was that, unless the horizontal axis was made very heavy it was weakened at a vital point.

FIG. 101



Improvement on Hulbert's Mine-Transit

Another method was to terminate the horizontal axis in an enlarged threaded hub beyond the outside of the standard and to screw the telescope on with a clamping-nut, but as the threads wore, the alignment of the telescope was destroyed; and while the parallelism of the two telescopes was not disturbed to any marked degree, the zero (level) points were, and it was necessary for the engineer to allow for this index-error, or insert a piece of tin-foil between the hub attached to the telescope and the side of the standards. Of late years it has been customary to add a tangent-screw or two opposing screws to remedy this objection.

Fig. 102*, illustrating the style in use at present (1899), is taken from a transit made for use in the Kimberley mines, South Africa. The auxiliary telescope is attached permanently to the vertical circle (5 in. in diameter and reading by a single vernier to one minute), and is provided with a clamp and a tangent-screw. The graduations are on the inside of the circle, to protect them from injury, and to facilitate the reading of the vernier. The telescope (non-extension, dust and water-proof), 7 in. long, is furnished with a diagonal (prism) eye-piece and a reflector for cross-hairs (the latter not shown in the figure). All the attachments, with the counterpoise, are detachable, and when they are not in use the engineer has still a complete transit, with all modern improvements, having graduations 6¾ in., level to telescope, clamp and opposing screws (not shown in the figure) and vertical arc.

* Fig. 102 is shown as Mining Transit No. 1, page 47, this catalogue.

Seventeenth Edition.

In presenting this edition of catalogue to our Engineering friends, we would state that our different instruments are generally selected as follows :—

No. 6 TRANSIT.—For Railroad work and General Practice in Cities. (Our Standard Transit for this work.)

No. 7 TRANSIT.—For Special City and Bridge work.

No. 10 TRANSIT.—For Mountain work.

No. 13 TRANSIT.—For Straight Lines in Cities and Tunnels.

No. 3 TRANSIT—For work of ordinary accuracy and for Surveyors.

LEVEL No. 1—18 IN. TELESCOPE.—For Railroad Level, and Level for General Practice in Cities. (Our Standard Level for this work.)

LEVEL No. 1—20 AND 22 IN. TELESCOPE, AND DENISON PATENT LEVEL.—For Special City, Bridge and Hydraulic work.

LEVEL No. 3—18 IN. TELESCOPE.—For Rough work, and a Practice of ordinary accuracy.

LEVEL No. 2½—15 IN. TELESCOPE.—For work requiring a light Level.

For further details consult next page and page No. 12. For Mining Transits, and Transits with Solar Attachment, consult page No. 12.

Read carefully remarks on the numbering of Horizontal Graduations on page No. 27, and extra large Vertical Arcs and Circles on page No. 56.

The Verniers on all our Transits are placed to one side of standards for convenience in reading, just as they have been placed on all our Transits for the last 50 years. (See page 25.) Reflectors are placed over all the Verniers of all Transits.

Caps will be placed over Leveling Screws *when desired* without extra charge.

Respectfully,

YOUNG & SONS.

Philadelphia, Pa., July 1, 1901.

NOTICE.

Prices given in this Catalogue for:

Transit No. 3,	. . .	*page No. 40,*
Transit No. 6,	. . .	*page No. 41,*
Transit No. 7,	. . .	*page No. 42,*
Transit No. 10,	. . .	*page No. 43,*
Transit No. 13,	. . .	*page No. 44,*

Are all for Transit "with plain telescope," that is, without vertical circle, level or clamp and opposing screws. Prices for these extras will be found on page No. 47.